

AD-A098 314

PRC SYSTEMS SERVICES CO MELEAN VA
COMMERCIAL VESSEL SAFETY. ECONOMIC COSTS. PRELIMINARY. (U)
DEC 79 C A CROOK, M L PATTERSON

F/G 5/4

UNCLASSIFIED

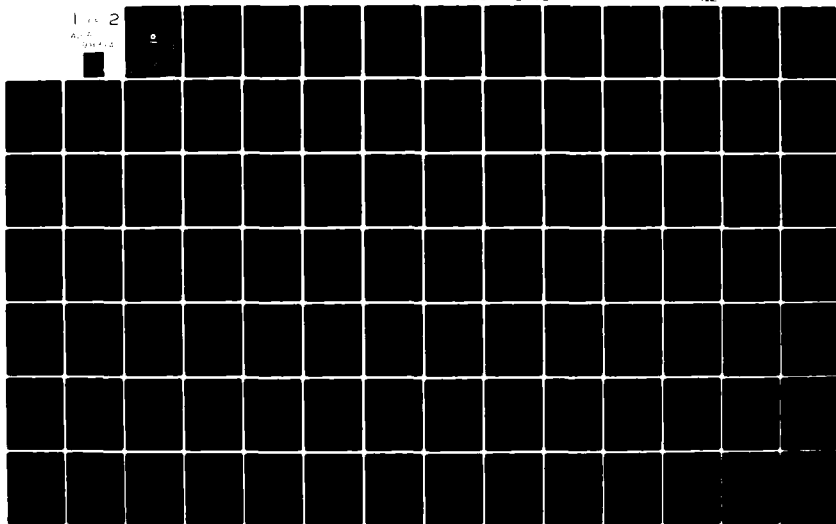
USCG-D-1-81

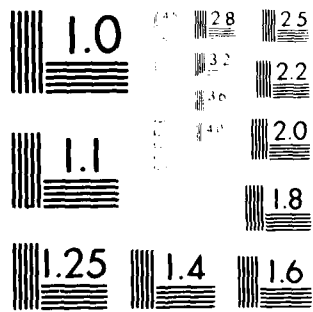
DOT-CG-351-A

NL

1 of 2

AD-A098 314





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

18 U.SCG-D

Report No. CG-D-1-81

12 LEVEL yw

6 COMMERCIAL VESSEL SAFETY.

A098313

ECONOMIC COSTS.
PRELIMINARY.

Planning Research Corporation
Systems Services Company
7600 Old Springhouse Road
McLean, VA 22102

9 Final rept. Sep 77-Dec 79

12 116



11 DEC 1979
FINAL REPORT

DTIC
ELECTE
APR 29 1981

15 DOT-CG-351-A

70 C.A./Crook M.L./Patterson W.R./Whittemore, Jr.
C.H./Hammond T.S./Boisvert

Document is available to the public through the
National Technical Information Service,
Springfield, Virginia 22151

Prepared for

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
Office of Research and Development
Washington, D.C. 20590

AD A098314

DTIC FILE COPY

411158 81 4 29 023

5013

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

The contents of this report do not necessarily reflect the official view or policy of the Coast Guard; and they do not constitute a standard, specification, or regulation.

This report, or portions thereof may not be used for advertising or sales promotion purposes. Citation of trade names and manufacturers does not constitute endorsement or approval of such products.

COMMERCIAL VESSEL SAFETY
ECONOMIC COSTS

Planning Research Corporation
Systems Services Company
7600 Old Springhouse Road
McLean, Virginia 22102

December 1979

FINAL REPORT

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The U.S. Government assumes no liability for the contents or use thereof.

Prepared for:

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD

Office of Research and Development
Washington, D.C. 20590

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No. AD-HO 98314	3. Recipient's Catalog No.	
4. Title and Subtitle Commercial Vessel Safety - Economic Costs		5. Report Date December 1979	
		6. Performing Organization Code	
7. Author(s) C. A. Crook, M. L. Patterson, W. R. Whittemore, Jr. C. H. Hammond, T. S. Boisvert, L. W. Goddu, Jr.		8. Performing Organization Report No.	
9. Performing Organization Name and Address Planning Research Corporation Systems Services Company 7600 Old Springhouse Road McLean, VA 22102		10. Work Unit No.	
		11. Contract or Grant No. DOT-CG, 351-A	
12. Sponsoring Agency Name and Address U.S Coast Guard Office of Research and Development Washington, D.C. 20590		13. Type of Report and Period Covered Final Report September 1977 - December 1979	
		14. Sponsoring Agency Code G-DMT-1/TP54	
15. Supplementary Notes U.S. Coast Guard Technical Project Leaders were Dr. John Gardenier and LCDR Frank J. Scaraglino. Project Monitors/Test Case Coordinators were LCDR James Townley, CDR Gerald Barton, LCDR Michael Armstrong, CDR Richard Hess, LCDR Theodore Sampson and Dr. James Veatch.			
<p>16. Abstract</p> <p>The effort documented in this report provides methods and procedures for the U. S. Coast Guard's economic assessment of regulatory actions under the Commercial Vessel Safety Program. Three distinct tasks were undertaken: a survey of cost-benefit methodologies; development of a methodology and procedures for estimating the costs of regulatory actions; and an exercise of the procedures.</p> <p>The methodology survey involved a literature search of studies, reports, regulations and economic models. The direction of the survey was divided into two major parts. First, the determination of applicable procedures for estimating direct costs to industry and Government. Second, the determination of cost impacts as they are passed through the economy.</p> <p>The development of a methodology and procedures for assessing the costs and cost impacts of Coast Guard regulations involved the development of step-by-step procedures in a "how to" manual format for regulations that effect: vessel design, vessel equipment, vessel staffing, vessel licensing, vessel inspection and vessel operating costs. The procedures describe, for each cost element, what to look for in developing costs, pitfalls to be avoided and sources for cost inputs. Input-output techniques, using the University of Maryland's INFORUM model, are used to trace the cost impacts of regulatory actions.</p> <p>Three exercises were carried out to test the manual procedures on current Coast Guard regulatory issues. The subjects of the exercises were: Example I: Proposed Tankerman Regulations; Example II: Double Hull Retrofit for Existing Tank Barges; Example III: Vessel Delays at the Hackensack River Portal Bridge. (NOTE: These exercises are unpublished)</p>			
17. Key Words Cost-benefit analysis Coast Guard economic regulation analysis Maritime economics Transportation economics Regulatory cost		18. Distribution Statement Document is available to the public through the National Technical Information Service, Springfield, VA 22151	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 277	22. Price

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
in	inches	2.5	Centimeters	cm
ft	feet	30	Centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
AREA				
sq in	square inches	6.5	Square centimeters	cm ²
sq ft	square feet	0.09	Square meters	m ²
sq yd	square yards	0.8	Square meters	m ²
sq mi	square miles	2.6	Square kilometers	km ²
acres	acres	0.4	hectares	ha
MASS (weight)				
oz	ounces	28	Grams	g
lb	pounds	4.6	Kilograms	kg
	short tons	0.9	tonnes	t
	(2000 lb)			
VOLUME				
cup	teaspoons	5	milliliters	ml
1/2 cup	tablespoons	15	milliliters	ml
1 qt	fluid ounces	30	milliliters	ml
1 pt	cup	0.24	liters	l
1 qt	quarts	0.97	liters	l
1 gal	gallons	3.8	liters	l
1 cu ft	cubic feet	0.03	Cubic meters	m ³
1 cu yd	cubic yards	0.76	Cubic meters	m ³
TEMPERATURE (exact)				
°F	Fahrenheit temperature	5/9 after subtracting 32	Celsius temperature	°C

* 1 in = 2.54 cm exactly. For other exact conversions and more detailed tables, see NIST Spec. Publ. 280, Units of Weight and Measure, Price \$2.95. 50 Catalog No. C13 10-280.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
LENGTH				
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
km	kilometers	1.1	miles	mi
		0.6	miles	mi
AREA				
cm ²	square centimeters	0.16	square inches	in ²
m ²	square meters	1.2	square yards	yd ²
km ²	square kilometers	0.4	square miles	mi ²
ha	hectares (10,000 m ²)	2.5	acres	ac
MASS (weight)				
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
VOLUME				
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
m ³	cubic meters	0.26	gallons	gal
m ³	cubic meters	36	cubic feet	ft ³
m ³	cubic meters	1.3	cubic yards	yd ³

TEMPERATURE (exact)

°C	Celsius temperature	9/5 then add 32	Fahrenheit temperature	°F
-40				-40
-20				-4
0				32
20				68
32				90
40				104
60				140
80				176
100				212

TABLE OF CONTENTS

	<u>Page</u>
EXECUTIVE SUMMARY	1
I. INTRODUCTION	7
II. METHODOLOGY SURVEY	9
III. DESCRIPTION OF THE DEVELOPMENT OF ESTIMATION PROCEDURES FOR COSTS AND COST IMPACTS OF MARINE SAFETY REGULATIONS	81
IV. DESCRIPTION OF PROCEDURE TESTS	99
V. RECOMMENDATIONS	103
VI. BIBLIOGRAPHY	105
APPENDIX A ESTIMATION PROCEDURES FOR COSTS AND COST IMPACTS OF MARINE SAFETY REGULATIONS	Separate Volume
APPENDIX B PROCEDURE EXAMPLES	Unpublished

RECEIVED
 FBI
 MAY 19 1964
 DISC
 Special

EXECUTIVE SUMMARY

The U. S. Coast Guard has as one of its primary functions the promulgation and enforcement of regulations to enhance the safe operation of commercial vessels in U. S. navigable waters and to protect the marine environment. The work effort documented in this report had three objectives. First, a survey of methodologies applicable to the assessment of costs of Coast Guard regulatory and enforcement actions. Second, the development of a methodology and set of procedures that could provide the basis for a theoretically sound and defensible methodology for analyzing costs and cost impacts as part of the Coast Guard decision making process. Third, the demonstration of the methodology by estimating the costs of three different Coast Guard actions to the Government, maritime industry and economy as a whole.

A. Methodology Survey

The survey involved a literature search of a large number of studies, reports, notices, regulations and econometric models. The direction of the survey was divided into two major parts.

1. *Determination of Costs* - here the objective is to determine the direct costs which accrue to the Coast Guard or industry as the result of implementing a regulation.
2. *Determination of Cost Impacts* - the objective of this segment is to measure and trace the impact of costs as they are transferred or "rippled" through the economy when a regulation is implemented.

The survey associated with determination of costs focused upon two basic areas: procedures to estimate costs accruing directly to the Coast Guard (e.g., in-house) and, secondly, costs accruing to the commercial shipping industry as a result of Coast Guard actions. Survey of the first segment turned up the fact that, while there exist some factors to estimate in-house costs such as personnel compensation/unit of labor, no formal procedure exists to allocate such costs to an action, in this case, conception, development and implementation of a regulation.

The findings of the second segment of "determination of costs" were similar to the in-house costing situation. Here attention was focused on available techniques such as cost estimating relationships (CERs) to estimate ship construction costs. A problem with CER's is that by changing one assumption or the magnitude of one data point changes the expected value, often rendering the technique useless for estimating new or different situations.

The survey portion dealing with determination of cost impacts was likewise divided into two principal segments:

- Microeconomic Analysis
- Macroeconomic Analysis

The microeconomic analysis portion looked at available procedures to trace the impacts of a cost change (e.g., increase in commodity prices resulting from a regulation change) as it relates to a particular industry. The major finding of this portion of the survey was that while generalized methods have been developed to analyze industries, refined procedures must be tailored to the characteristics of each individual industry.

The macroeconomic analysis portion of the survey presented a different situation. As expected, the survey showed there are input-output models available which are purported to be able to show the national economic impact if a variable is changed (e.g., a regulation change that may result in large price increases). A major problem associated with use of such models is the magnitude of the change required in a variable before a nationwide "ripple" can be discerned.

A final segment of the determination of cost impact section is devoted to a brief overview of the maritime industry. The purpose of this section is to relate the complexities of salient characteristics of the marine industry.

A general conclusion drawn as the result of the methodology survey is that while there are scattered factors, limited procedures, methodologies and models available which may be applied to individual segments of the cost-benefit analytical framework to be developed, a cohesive set of procedures would require weaving these bits and pieces together and developing new procedures where gaps existed.

B. Cost Procedures Manual

The objective of the Cost Procedures Manual is to apprise decision makers of the relative costs of regulatory actions. To achieve this it was necessary to develop a methodology and set of procedures for systematically analyzing and estimating the costs and cost impacts of Coast Guard regulatory actions.

Cost-benefit procedures can be used to find the most economically feasible alternative among regulatory alternatives. In order to compare alternatives a number of issues must be decided. First is the choice of the appropriate cost methodology. Generally, it was found that the life cycle cost methodology provided the most accurate estimates, at an appropriate level of detail and with sufficient flexibility to handle the analysis of regulations likely to be proposed under the Commercial Vessel Safety Program.

Second, since most regulations have cost and benefit impacts over time any analysis must be done over a period of years, usually less than 25, that is appropriate for the regulation under consideration. Third, it is essential to recognize the time value of money in cost-benefit analysis since many regulations involve a commitment of resources over a period of time. The recommended approach is to discount future expenditures to their present value. One potentially complicating factor in this type of analysis is inflation. Only in cases where long term escalation of some factor is expected to be abnormal should an adjustment be made for inflation.

The cost procedures are presented in a "how to" type of manual format to provide step-by-step instructions for several potential types of regulatory areas under Coast Guard jurisdiction.

The manual procedures are divided into two sections: Costs; and Cost Impacts.

Costs

The cost procedures are organized into six parts: vessel design, vessel equipment, vessel staffing, vessel licensing, vessel inspection and vessel operating costs. Potential cost elements to be considered by the regulatory staff are provided. In addition, each section details what to look for in developing costs, pitfalls to be avoided and sources for cost inputs.

The procedures have a number of limitations. One significant difficulty in performing cost-benefit analysis is data. Important data may not be available, it may not be available at an appropriate level of detail, or the regulatory staff may not be able to investigate the sources of the data. A further constraint is the level of detail of the casualty data bases on which risk assessments are made.

Cost Impacts

The costs and subsequent price increases incurred by Government and industry as a result of regulatory actions will be passed on to other industries and consumers. Therefore it was necessary to develop a method to trace these impacts through the economy.

One method of tracking these impacts is the use of input-output techniques. The Procedures Manual recommends the use of the University of Maryland's INFORUM model. It provides the capability to trace interindustry impacts in the petroleum and water transportation sectors if the price increases in either sector are of sufficient magnitude to impact the model. Use of this model has certain limitations. First, many regulations will not generate sufficient price increases to impact the model. Second, the model's data base is not the best available. Third, the model is expensive to run. Fourth, the model was designed forecasting economic activity nationally and by major sectors; it must be carefully adapted to regulatory impact analysis by someone intimately familiar with the model's structure and assumptions.

C. Procedure Examples

Three exercises of the manual procedures were conducted. The issues chosen involved two proposed regulatory actions and one on-going vessel operational problem. The subjects for the three examples were:

Example I: Proposed Tankerman Regulations

Example II: Double Hull Retrofit for Existing Tank Barges

Example III: Vessel Delays at the Hackensack River Portal Bridge

The examples provided an opportunity to test the manual procedures for regulations that impact vessel personnel licensing, vessel design and vessel delays. Due to the limited time available for each exercise, the procedures applicable to the assessment of cost impacts were not tested.

The purpose of the examples was to exercise the procedures and to provide the Coast Guard regulatory staff with samples of the application of the procedures to three current regulatory issues. The approach, level of detail and identification of key issues and potential problems encountered in these examples provides useful guidance for future, similar, regulatory analyses.

SECTION I

INTRODUCTION

The Coast Guard has the responsibility for administering and enforcing laws, rules and regulations associated with navigation and inspection of vessels, marine environmental protection, and ports and waterways safety. This responsibility includes the promulgation and implementation of regulations that have an economic impact on Government, industry and consumers. In this context, one of the Coast Guard's objectives is to develop a methodology and procedures for assessing these economic impacts. The purpose of these procedures is to provide a standard method of comparing the costs of alternative courses of action.

To support this effort a study was undertaken to: (1) survey existing cost methodologies to determine their applicability to Coast Guard regulatory and enforcement actions; (2) develop a cost analysis methodology and procedures for assessing the impacts of Coast Guard programs; and, (3) exercise the procedures for three Coast Guard actions producing a variety of cost impacts. The results of the study are documented in this report.

The methodology survey focused on cost methodologies potentially able to measure the costs of regulations accruing to the commercial shipping industry and Coast Guard, and the final impacts of costs on segments of the economy or the economy as a whole. Of the cost methodologies surveyed, no one existing methodology was directly applicable to the cost-benefit analytical framework required for analysis of Coast Guard actions. Scattered existing factors and procedures as well as new procedures were required to develop procedures for comparing alternative Coast Guard actions.

The procedures manual provides a systematic method of assessing the costs and cost impacts of proposed Coast Guard regulations under the Commercial Vessel Safety Program. Specific procedures were designed for estimating the costs of regulations that affect vessel design, equipment, staffing, licensing, inspection and Coast Guard in-house training. Development of these procedures was accomplished with several considerations in mind to ensure the usefulness of the procedures to the Coast Guard regulatory staff. These considerations were:

- Sophistication - are the mathematical or statistical techniques employed in the procedures too complicated or confusing to all but the most skilled analytical technician?
- Level of Detail - is the level of detail of the procedures such that massive data collection and time-consuming input formulation/manipulation can be avoided to arrive at reasonable results?
- Flexibility - are the procedures capable of being exercised for generic groups (e.g., ports or vessels in general) or must the analyst be specific.

Three examples were provided to demonstrate the application of Cost Manual procedures. The subjects for these test cases were:

- Proposed Tankerman Regulations
- Double Hull Retrofit for Existing Tank Barges
- Vessel Delays at the Hackensack River Portal Bridge

These examples demonstrate the use of the manual procedures applicable to training, vessel design and vessel delays.

This report is divided into Sections as follows. Section II contains the Methodology Survey. Section III describes the approach, capabilities and limitations of the Cost Procedures Manual. The Procedures Manual itself is contained in Appendix A, under separate cover. Section IV describes the three examples of the Procedures Manual. The results of each of the examples are included in Appendix B, a separate volume. Section V contains recommendations for further research. Section VI provides a bibliography of maritime industry cost-benefit analysis references.

SECTION II

METHODOLOGY SURVEY

INTRODUCTION

This Section of the report addresses itself to methods for determining the cost of alternatives which fall under the aegis of the Commercial Vessel Safety Program. It surveys methodologies which address the cost side of Coast Guard actions. The survey involved a literature search of a large number of studies, reports, notices, regulations and econometric models. A survey of existing methodologies was done to avoid duplication of effort in the development of cost procedures and to provide a capability to build on applicable procedures or techniques which were available. Beyond this survey, the next steps involve developing, adapting, and combining cost methodologies to fit the regulations under study.

The delineation between the measurement of costs and benefits and their impact corresponds to the division between efficiency and equity considerations in public policy making. Cost-benefit analysis is a technique for applying economic efficiency criteria to policy alternatives. It is used to determine if the value of what is produced by a certain action or expenditure is greater than the value of the resources used. Cost-benefit analysis requires the costs and benefits associated with a certain action be aggregated without regard to the individual or group to whom they accrue. The magnitudes of the costs and benefits that result are compared, and the analyst can determine, based on efficiency criteria, the best alternative to choose.

In contrast, equity considerations involve determining who pays the costs and reaps the benefits of alternative actions after they have been passed on through the economy. This information can be used by the decision maker to determine if, on equity grounds, different weights should be placed on the dollar values of costs and benefits according to who bears them.

By separating the magnitude of costs and benefits from their impacts, the problem of double counting can be avoided. This problem arises when costs or benefits which accrue initially to one group but which are passed on to other groups are included more than once in measurement calculations.

The cost methodology survey is divided according to efficiency and equity aspects. Part 1 reviews methodologies which address cost measurement, and part 2 reviews methodologies which address cost impacts. Part 3 contains the findings. Before the directions of parts 1 and 2 are described in greater detail, it is useful to note some theoretical considerations associated with estimating costs and their impacts.

- The group for which costs are being measured must be identified. Usually, cost-benefit analyses are undertaken on behalf of the whole nation with no import attached to costs and benefits accruing to groups in other nations. Accordingly, the analysis of Coast Guard regulations is limited to the measurement of costs borne by U.S. individuals and groups. Costs borne by foreign groups will be addressed only if they are passed onto U.S. citizens or residents.

- In determining the costs and benefits of an action, it is important to include the externalities, both positive and negative, which result. Externalities can be defined as indirect spillover effects; effects on third parties which are not included in the economic decision-making process. Externalities arise when relevant effects of any economic activity are wholly or partially unpriced. In the cost-benefit analysis, the dollar value of significant externalities must be determined. Unfortunately, many of the externalities cannot be quantified because of lack of data and poor estimation techniques. In this circumstance, the externalities must be listed and described in as much detail as possible.

- Finally, it is important to measure only the costs attributable to the regulations themselves. For example, care must be taken not to measure the total costs of construction or operation to the commercial shipping industry but only the incremental operating or construction costs caused by compliance with the subject regulations.

The costs of Coast Guard regulations may be borne initially by many different groups. However, for the great majority of regulations, the regulation costs will fall on two major groups: the commercial shipping industry which must comply with the regulations and the U.S. Coast Guard which develops, administers and enforces the regulations.

Part 1 focuses on cost estimating methodologies potentially able to measure the costs accruing to these two groups. Section 1.1 concentrates on Coast Guard costs. No one methodology exists to measure the incremental costs of regulations to the Coast Guard. However, section 1.1 discusses those aspects of Coast Guard budget and management documents which provide a start for estimating these incremental costs.

Section 1.2 concentrates on estimating costs to the commercial shipping industry. It contains reviews of cost-estimating methodologies which have been applied to shipping

costs. The methodologies, and the studies which use them, are evaluated in terms of their applicability for measuring the incremental costs to industry of Coast Guard regulations.

Part 2 focuses on methodologies which isolate the final impacts of costs on segments of the economy or on the economy as a whole. The methodologies included fall into two broad categories: methodologies employing microeconomic analysis to determine impacts on industries and methodologies employing macroeconomic analysis to determine impacts on economy-wide indicators.

Three studies which have employed both micro- and macroeconomic methodologies to assess the distribution of costs of regulations similar in nature to the Coast Guard regulations are reviewed and evaluated. Section 2.1 discusses the microeconomic side of the methodologies and section 2.2 discusses the macroeconomic side. Section 2.3 contains an overview of the commercial shipping industry which illustrates certain problems involved in applying the methodologies to that industry.

1. DETERMINATION OF THE COSTS OF PROPOSED COAST GUARD REGULATIONS

The methodologies surveyed were chosen because they given the most promise of aiding in the determination of the costs of Coast Guard regulations. The methodologies will be discussed in two separate sections. First, methodologies for measuring the costs to the Coast Guard will be presented and, second, cost-estimating methodologies applicable to the commercial shipping industry are discussed.

1.1 COSTS TO THE COAST GUARD

The survey of available methodologies to measure the costs to the Coast Guard of Commercial Vessel Safety (CVS) Program regulations included examination of Coast Guard documents (including the Coast Guard Budget) and interviews with Coast Guard personnel. PRC/Systems Services Company found there is no one existing methodology for determining the costs in terms of resource requirements of regulations to the Coast Guard. The resource requirements of a regulation are the personnel, material, and facilities associated with a regulation from its development through enforcement. The Coast Guard does not account for costs in terms of implementing new regulations. The methodology survey has indicated that several Coast Guard documents contain methods for measuring costs on bases other than a regulation.

Other internal accounting systems within military organizations were evaluated to gain insight into the problem. For example, the principal mission-oriented activity of the U.S. Army in peacetime is training. None of the available Army handbooks or manuals show cost factors for determining the costs of training a tank battalion in the field for a week. Many variables are involved in estimating these costs and, as a result, it is impractical to arrive at a reasonable range of costs, much less a point estimate depending on the level of activity of that unit in the field.

A similar situation is observed when assessing methodologies for estimating incremental costs to the Coast Guard resulting from new regulations. This paper addresses the CVS Program's and the Coast Guard's internal accounting methods and other applicable factors which can be put together to measure regulation costs. Gaps which call for potential development of new methods or factors will be assessed whenever they appear to exist.

The organization of this section is as follows:

- A brief description of the salient contents of applicable documents.
- A discussion concerning the applicability of the documents evaluated and the availability of data.

1.1.1 Document Description and Evaluation

1.1.1.1 Marine Safety Manual MSM CG-495¹

The Marine Safety Manual presents the Coast Guard's responsibilities for administering and managing the CVS Program, the Port Safety and Security (PSS) Program, the Marine Environmental Protection (MEP) Program, and certain functions of the Recreational Boating Safety (RBS) Program. It delineates the tasks for personnel at the headquarters, district, and field office level for carrying out these programs. The administration and enforcement of CVS regulations are primarily performed at the field office level, i.e. in Marine Inspection Offices (MIO) and Marine Safety Offices (MSO).

Tasks carried out at the MIOs fall under the auspices of the CVS Program. Tasks performed at the MSOs may fall under the CVS, MEP, and PSS Programs. Resources are assigned to each MIO and MSO, not to individual programs. This study is concerned solely with the resources used by the CVS Program. The MSM can aid in determining these resources because it delineates the functions at the MSOs that fall under the CVS Program, as opposed to the MEP or PSS Programs. An organization chart is presented in figure 1 to help explain the structure of an MSO.

1.1.1.2 Operating Program Plan for the Commercial Vessel Safety²

The Operating Program Plan outlines the objectives and activities of the CVS Program and task elements performed at the field level. They include: (a) vessel and factory inspections; (b) casualty and personnel investigations; (c) licensing and certifying of merchant seamen; (d) shipment and discharge of seamen; (e) vessel documentation; and (f) plan review services. Similar task elements are grouped together within the plan and are defined as program elements. The person-hours required to perform the task elements of all but research and development (R&D) are presented in the plan. The resource requirements of R&D are distributed at the headquarters level, not the field level.

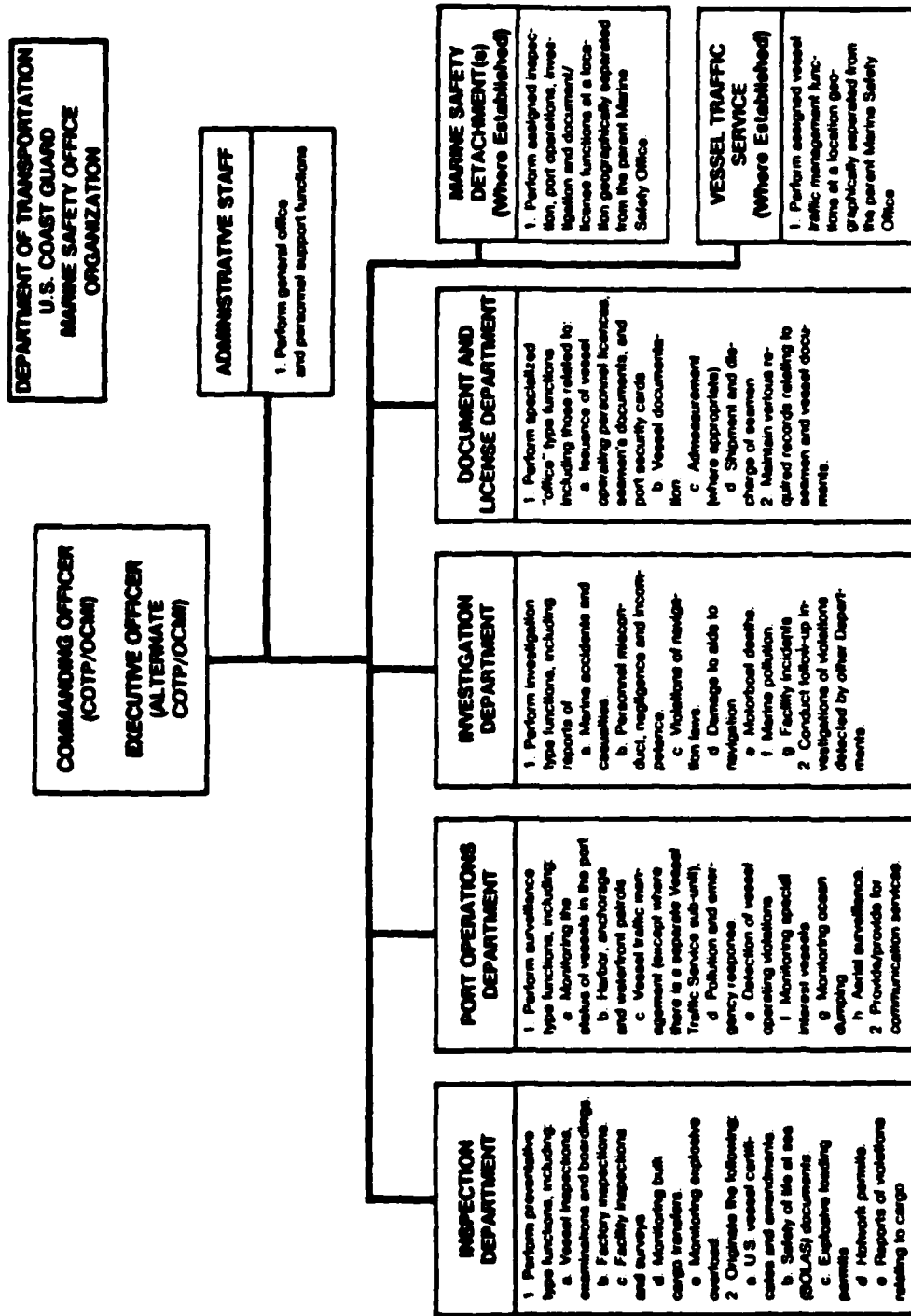
Once the task elements needed to administer and enforce a CVS regulation have been identified, the Operating Program Plan shows the person-hours required to perform the task elements.

1.1.1.3 Marine Inspection Office Workload and Billet Distribution Study³

The objective of this study was to "determine whether the existing personnel allowances for the various MIOs are justified based on current workloads, and (to) develop a method to monitor distribution of personnel annually using workload versus personnel allowance based on statistical information contained in reports periodically submitted by each MIO." In fulfillment of these objectives, procedures are presented for determining:

MARINE SAFETY MANUAL (CG-495)

FIGURE 1. MARINE SAFETY OFFICE ORGANIZATIONAL CHART



NOTE:

This prescribes the organization pattern for a typical Marine Safety Office. At any particular Marine Safety Office, the number and groupings of Departments (then Divisions, then Branches) shall be tailored to best match available personnel levels to the assigned missions and specific workloads.

Source: Marine Safety Manual CG 495

(1) the number of officers needed in each MIO; and (2) average person hours utilized per work component. Examples of work components for the CVS Program are found in Appendix A.

The procedure for estimating the number of officers per MIO is described below:

$$Z = \frac{W_1}{W_2} \times 1.15 + \frac{TR(1)}{2}$$

where

Z = number of officers needed in each MIO

W_1 = workload or work components performed at the MIO

W_2 = manpower available at the MIO

TR = number of trainees (a trainee is assumed to be 50 percent as effective as an experienced officer)

The constant, 1.15, accounts for administrative workload. W_1 can be defined as the summation of hours spent performing the following functions at MIOs:

V = vessel inspections

I = casualty, personnel, motorboat investigations

L = licensing and seamen documentation

NC = new construction and conversion

F = factory inspections

SC = shipment and discharge of seamen

T = time spent on travel⁴

W_2 is defined as 1,680 person-hours. Therefore:

$$Z = \frac{V + I + L + NC + F + SC + T}{1,680} \times 1.15 + \frac{TR}{2} \quad (2)^5$$

The estimates for work components performed, W_1 , were obtained from: (1) forms requesting person hours spent in each work component category at each MIO; and (2) on-scene time studies conducted upon a random sampling of MIOs. The guidelines for filling out these forms were:

1. Indicate the best estimate of the average person-hours needed to perform each of the components.
2. Include only person-hours spent by inspectors.
3. Do not include travel time (this is separate component).
4. Do not include person-hours spent performing clerical tasks.
5. Include in person-hours for licensing only time spent reviewing applications, interviewing, pulling examinations, correcting examinations, and final interviewing and processing; do not include time spent monitoring.
6. Person-hours for factory inspections must show specific types of inspections using item quantities per hour or how many hours per item if a single item requires one or more person-hours per item.
7. Travel must indicate miles per hour estimated as average for each category (in and out of town).
8. Shipping commissioner functions must indicate estimated average number per hour signed-on and off.⁶

Although the main focus of this study is MIOs, it also addresses some of the problems in determining the personnel requirements for the CVS Program at the multi-program MSOs. The study presents figures which illustrate the breakdown of work components performed at MSOs for CVS and other programs. The breakdown for non-CVS programs and activities is presented in Attachments B and C. By analyzing these figures, estimates for the work components performed on the CVS Program at MSOs can be obtained.

Given the work components performed on the CVS Program at MIOs and MSOs, the personnel costs of a regulation can be defined as the increment of person-hours above these established component levels. This definition of personnel costs depends upon the following assumptions:

- There is a good correlation between the work components of a regulation and those delineated in Attachment A.
- When several new regulations are established, the components of a specific regulation can be differentiated from the components of the other regulations.

1.1.1.4 Commandant Notice 7100. Subject: Annual Standard Personnel Costs⁷

Commandant Notice 7100 provides: (1) civilian and military annual standard personnel salary costs in dollars; and (2) civilian and military annual standard personnel support costs in dollars. Support activities are defined as: (a) costs associated with permanent change of station program; (b) operating and maintenance costs; and (c) personnel training and procurement costs. These figures are used in the preparation for each fiscal year's budget. The information contained in the notice can be used to convert incremental person-hours spent on regulations in the CVS Program into personnel salary and support costs in dollars for the fiscal year.

1.1.1.5 Enclosure to COMDTINST 16465.2 Series. Subject: Standard Rates⁸

Included in this notice are the standard rates of operating Coast Guard cutters, aircraft, small boats, and owned and/or leased vehicles in pollution incidents. Costs of operations are broken down by "personnel, fuel, depreciation and other." Personnel, depreciation, and other costs are derived from historical data. Exceptions to historical data are allowed for fuel costs because the real cost of fuel is a function of actual consumption and price. Overhead expenses are stipulated as being 25 percent of personnel, fuel, and other costs. The cost estimates presented in this enclosure may be used to approximate the costs incurred by the CVS Program in using these vehicles.

1.1.2 Discussion

The Coast Guard has several methodologies and standard factors which, when used together, can determine some of the costs of developing and implementing new regulations. The development of a complete methodology based on existing Coast Guard accounting techniques which, at present, do not directly estimate the costs of regulations, must address the following considerations.

To measure the personnel cost of a regulation, a correlation between task elements (including R&D allotments) or work components and the specific regulations must be established. A regulation may correlate with one or more task elements or work components. At this time, it is uncertain to what extent R&D costs can or should be allocated to or forecast for specific regulations. The establishment of this correlation would require that a work breakdown be performed for each proposed regulation. The breakdown should be carried out at a level of detail equivalent to a task element or work component. The difficulty with breaking down a regulation into task elements or work components lies with the inability of the written regulation to clearly define the specific duties associated with its enforcement. Once the duties are defined, they should approximate the activities performed by the relevant task elements or work components.

After incremental personnel requirements of a regulation have been established, the next step is the assessment of the incremental material and facility requirements. Estimation of the costs associated with these additional material and/or facilities requirements will utilize standard Coast Guard factors (e.g., General Services Administration Standards).

1.2 COSTS TO THE COMMERCIAL SHIPPING INDUSTRY

The studies included in this section were chosen through Coast Guard guidance in some cases and in others because they apply theoretical cost estimating procedures to the shipping industry. One study is presented as the representative of the application of a life-cycle cost methodology to estimate the costs of alternative regulations. It is recognized that other studies utilize life-cycle cost analysis. However, the analyses utilized in the different studies are consistent in their application of standard financial principles and in their utilization of basic ship cost components (e.g., investment and operating costs). Even though the actual working definitions utilized within these gross components differ somewhat by study, their methodological treatment does not. The establishment of appropriate definitions for cost components will be undertaken in the procedure development portion of the task.

The survey of cost estimating procedures includes those studies that apply both cost estimating relationships and engineering costing techniques* to vessel cost problems. The application of analogy costing and Delphi costing techniques are also identified as alternative methods to determine the incremental costs due to changes in Coast Guard regulations.

Initially, the representative studies are discussed in terms of their treatment of cost estimating techniques and their general applicability to our task. A summary presentation of the potentially applicable techniques in the context of a general life-cycle cost framework is also provided. Specific emphasis is placed upon the applicability of techniques to estimating the costs of varying types of proposed governmental actions which affect:

- a. Vessel design criteria, including cargo size limits for specific cargoes, compartmentation criteria, and structural and stability requirements.

* An appendix of definitions of technical cost terms is attached as attachment D.

- b. Vessel equipment criteria such as navigation or communication requirements or cargo control equipment.
- c. Vessel staffing and licensing criteria.
- d. Vessel inspection intervals and requirements.
- e. Any operational controls such as those resulting in delays (lengthening routes, reducing speeds, or requirements to delay port transit).

1.2.1 Selected Studies

1.2.1.1 The Economic Value of the U.S. Merchant Marine¹⁰

The United States' policy of providing support to the commercial shipping industry has been historically justified on the basis of commercial benefit and military preparedness. This study examines and assesses only the commercial benefit or "economic value" of the merchant marine. Integral to the determination of the economic value of the merchant marine is the estimation of the initial and recurring costs incurred by ship owners/operators.¹¹

The model developed cost estimating relationships to express the quantitative relationships between the operating costs (capital costs are amortized and viewed as an operating cost) of a general cargo ship and their determinants. The components of vessel operating costs presented in the study depend upon parameters including the physical properties of the ship, the specifications of the trade route, and the structure of factor prices. The study utilized the performance (carriage capacity) of the voyage, rather than the weight of the cargo carried by the vessel, to determine the operating costs of a particular vessel. Therefore, this analysis concentrates on the estimation of costs per ton of capacity provided.

The basic unit for analyzing ships' costs used is a single voyage (round trip) on a particular route. Other units of measurement include (1) annual ship costs, (2) total costs over the life of the ship, and (3) costs per day at sea or per day in port. The unit of a single voyage was chosen because it can be easily converted to any of the other units.¹²

The aggregate costs of a single voyage can be expressed by the following relationship:

$$C = C_f + C_l + C_k + C_m + C_b \quad (3)$$

where each of the components of costs is defined as follows:

- C = total costs of a single voyage
- C_f = costs of fuel consumed on a single voyage, both at sea and in port
- C_l = labor costs at sea and in port including (a) the earnings of seamen, (b) supplements to earnings, such as contributions for social insurance and for welfare and pension plans, and (c) subsistence costs of the crew
- C_k = the costs of the ship including (a) amortization of the initial construction costs of the ship, (b) insurance expenses, and (c) miscellaneous "other" vessel operating expenses
- C_m = the maintenance costs of the ship (the sum of repair and maintenance plus store expenses)
- C_b = port dues and charges (the cost for port taxes, pilotage, dockage, wharfage, anchorage, etc.)¹³

Using least squares regression, the determinants of each component cost were derived and the resulting CERs presented in reduced form. The derivation of these reduced form equations, (4) through (8) was presented in the study's appendix B.¹⁴ The structural equations behind the reduced form equations will not be presented here because it is the reduced form equations that are of principal interest. They are:

$$C_b = T(32 + .0065R) + B(227 + .0179R) \quad (4)$$

$$C_f = P_f \frac{D}{24V} (14,400 + 12H) + 20,000T \quad (5)$$

$$C_l = \frac{D}{24V} + T P_l (30.9 + .00043R + .154H^{1/2}) \quad (6)$$

$$C_k = \frac{D}{24V} + T P_k = \frac{D}{24V} + T 1 + K_1 + K_2 Z(K) \quad (7)$$

where $K = 668R + 29,600H^{1/2}$

$$C_m = \frac{D}{24V} + T (186 + .0000186K) \quad (8)$$

The total costs of a single voyage can be expressed as a function of the above explanatory variables or parameters by substituting in equation (3) the expressions used in equations (4) through (8). This produces equation (9):

$$C = \frac{D}{24V} (14,400 + 12H)P_f + \frac{D}{24V} + T \cdot P_1 (30.9 + .00043R + .154H^{1/2}) + (186 + .0000186K) + (1 + K_1 + K_2) \cdot Z(668R + 29,600H^{1/2}) + (32 + 20,000 P_f + .0065R) + B(227 + .0197R) \quad (9)$$

where:

- H = shaft horsepower of the engine at normal cruising speed
- R = ship size as measured by the cubic number
- V = normal design speed in knots
- B = number of ports of calls
- D = the round voyage distance in nautical miles
- T = time in port days
- K = initial construction (or purchase) cost of the ship
- P_f = the price per pound of bunker "C" fuel oil, in dollars
- P_1 = the average daily wage per seaman including supplements and subsistence
- P_k = the daily capital charge of the ship which, in turn, depends upon K and upon:
- K_1 = the average ratio of insurance expenses to the implied daily amortization of the initial ship cost
- K_2 = the average ratio of other vessel operating expenses to the implied daily amortization of the initial cost of the ship, and
- Z = a factor to convert the initial ship cost to a daily amortization rate¹⁵

From equation (9) other units of measurement can be derived:

- Let $N = \frac{D}{24V} + T$ where:
 N = number of days required for a single voyage;¹⁶ dividing equation (9) by N gives voyage cost per day; multiplying the cost per day by T gives cost per day in port; multiplying the cost per day by $\frac{D}{24V}$ gives cost per day at sea.
- Given the dollar estimates of the factor prices, cost per ton-mile is calculated by dividing (9) by D .
- Annual ship costs and total costs over the life of the ship can be calculated by multiplying (9) by the expected number of voyages per year or per life, respectively. The present worth (life-cycle cost) of the ship could be determined by applying the appropriate discount factor to the annual costs over the life of the ship. However, the study does not present an applicable procedure or technique for determining the life-cycle cost.

Statistical analyses were performed on several of the structural equations used to formulate the CERs. However, no statistical analyses were utilized to evaluate the predictive capabilities of the individual reduced form estimating relationships. Coefficients of determination (R^2) were calculated only for the structural equations determining labor and maintenance costs. The R^2 presented indicates a high degree of explanatory power for these equations.

Statistical tests were not performed for other than the labor and maintenance structural equations. Independent of the functional integrity of the estimated equations, the data used in the CER formulation must be updated in order to estimate parameters that would be presently useful. The CERs presented in this study are only applicable to dry-cargo freighters because data was obtained from these ship types only.

Because the CERs were derived from a system of simultaneous equations, each of the component costs are sensitive to changes in the values of several explanatory variables. The degree of influence that changes in regulatory action have upon the explanatory variables and, hence, the total costs of a voyage, will be discussed in the final section.

The relevance of this methodology for the case at hand is not found in the detail of the equations. Rather, it provides examples of the parameters that influence the costs of operating a ship regardless of vessel type and the kinds of assumptions and procedures necessary in cost estimating.

1.2.1.2 Ocean Transportation¹⁷

This study analyzes the development and status of ocean transportation and projects future trends in ocean shipping. Included in the study are a review of ocean transportation demand and supply, technology, and economics. Within the economics area, a model is presented which estimates cost estimating relationships for the transocean costs for tankers, bulkers, break bulk, general cargo containers, and barge carrier vessels.

The model is designed to provide the following measurements:

- Dollars per ton, from the ocean terminal at the point of origin to the ocean terminal at the point of destination.
- Total transit time, in days, from the point of origin to the point of destination.
- Cost and transit time detail for determining cargo waiting time, cargo and terminal cost, cargo insurance cost or claims cost, ocean transit time, and documentation cost.¹⁸

The input parameters were derived from (1) a design, capital and operating cost computer program; and (2) exogenous trade parameters, e.g., the value per pound of cargo. The data used for equation formulation was gathered from personnel associated with the maritime industry. Specific sources were not indicated.

An exhaustive mathematical delineation of all of the cost estimating relationships developed in this study and potentially applicable to the assessment of impacts due to Coast Guard regulations would be inappropriate for analysis purposes. However, a brief qualitative discussion of representative cost estimating relationships will be presented. To assess the ability of these CERs to determine the costs of regulatory actions, a sample of the parameters of the CERs that could be directly affected by changes in vessel design, will be presented. The capital costs of barge and container vessels are determined as follows:

$$CC_{ctr} = 500 \cdot I_{ctr} \cdot R_+ / 365 \quad (11)$$

$$CC_{bar} = .0005677 \cdot B_{cb} \cdot I_{bar} \cdot R_+ \quad (12)$$

where:

CC_{ctr} = capital cost per container vessel round trip

CC_{bar} = capital cost per barge vessel round trip

R_+	=	round trip time in days
I_{ctr}	=	total number of containers that the vessel requires
B_{cb}	=	bale cubic of barge, cubic feet
I_{bar}	=	total number of barges that the vessel requires ¹⁹

Changes in vessel design of a barge vessel could directly affect the bale cubic and, therefore, its capital costs. Changes in container ship design might directly affect the number of containers that the vessel requires and, therefore, its capital costs.

Examples of other component cost relationships which could be affected by new regulatory actions are discussed below. The labor ratio in a particular trade area might be altered because of the initiation of a new staffing regulation. Port costs would change as a result because the labor ratio in a trade area determines the port entry and exit costs in this model. The implementation of new operational procedures could affect the frequency of service (measured in days) for the five vessel types discussed in this study. The model depicts waiting time at a pier before loading (measured in days) as a function of the frequency of service. Therefore, the cost of a new operations regulation could be described in terms of additional or less waiting time at a pier, e.g., additional fuel and manning costs.

There are several drawbacks to using these CERs for the present study.

- (1) The validity of the estimating relationships is not certain, as neither statistical nor other types of analyses were done.
- (2) The formulae presented are only applicable to the five vessel types mentioned.
- (3) The data is outdated.
- (4) The cost of a regulatory action involving new equipment standards cannot be estimated using the CERs in this study because no determinants of equipment were formulated.
- (5) The CERs will only estimate the costs of regulations which impact the parameters of the equations. As a result, some costs will be overlooked. For example, in this study, maintenance and repair (M + R) costs are a function of the bale cubic. It is likely that the implementation of a new maintenance and repair standard will not affect the bale cubic. Hence, according to the CER in this study, these costs would not be affected by the regulations.

The significance of the study lies in pointing out why existing cost estimating relationships are often of no use in measuring the costs of regulations.

1.2.1.3 General Cargo Ship Economics and Design²²

The aims of this study are to (1) provide the basis for a rational approach to general cargo ship design, and (2) present a ship cost estimating methodology based on technical-economic relationships. The cost estimating relationships developed in this study are associated with the construction and operation of a general cargo ship. The technical explanatory variables utilized were taken from a cargo ship's transport capabilities (cargo weight and volume, sea speed, and endurance), and the architect's technical parameters (displacement and horsepower). From these relationships, CERs that measure components' and systems' levels of cost have been formulated. The data (cost and person-hour breakdowns) used for developing these CERs were gathered from nine unspecified organizations.

Due to the number of CERs presented in this study, a representative sample of components that could be directly affected by changes in vessel design will be presented.

The labor costs for hull and outfitting construction are determined as follows:

$$MH_s = C_1 \frac{W_s}{1000}^{0.85} \quad (13)$$

$$MH_o = C_2 \frac{W_o}{100}^{0.9} \quad (14)$$

where:

- MH_s = person hours used for hull construction
- W_s = net weight of steel
- C_1 = coefficient ranging from 68,000 to 140,000 depending upon efficiency of the yard with an average of 90,000
- MH_o = person-hours used for outfitting construction
- W_o = net weight of outfitting
- C_2 = coefficient ranging from 15,000 to 27,500, depending upon the efficiency of the yard, with an average of 20,000²⁴

Changes in general cargo ship design could directly affect the net weight of steel used in the hull and the net weight of material used in the outfitting and, therefore, the respective labor costs.

Examples of other component costs determined in this study that could be influenced by regulatory actions are discussed below:

- The number of crew members might be affected because of the implementation of a new licensing regulation. Because the cost of stores and supplies

are a function of the number of crew, the cost of store and supplies will change due to the new regulations.

- The initiation of a new equipment regulation could affect the normal shaft horsepower for a general cargo ship. In this study, a change in normal shaft horsepower would affect fuel consumption costs. Therefore, the cost of an equipment regulation could be described, in part, in terms of a change in fuel costs.

The validity of the CERs developed in the study is not known as neither statistical nor other types of analyses were done. The CERs presented are only applicable to general cargo ships and the data base must be updated to account for technical changes or changes in the prices of components. But again, the most devastating criticism is the restrictive parameters of the equation. For example, in this study, the total cost of the crew aboard a general cargo ship is described as being a function of cubic number and normal shaft horsepower. The implementation of a new manning or licensing regulation would probably affect the cost of the crew, but not the cubic number or normal shaft horsepower. Therefore, according to this relationship, a manning or licensing regulation has no influence upon the cost of the crew -- a questionable conclusion.

1.2.1.4 Tank Barge Study²⁵

The Tank Barge Study was undertaken to assess how structural damages, oil spills and economic factors could be affected by new regulation alternatives with respect to retrofit and new construction for oil carrying tank barges. Section III (Economics) of the Final Report uses a life-cycle costing (LCC) methodology to determine the total and incremental costs of various tank barge design alternatives intended to minimize oil pollution.²⁶ This section comes closest to addressing the same type of question as the one the present project is concerned with.

Data are taken from those tank barges that operate on United States inland waterways and are broken down into six categories. Barges in a given category are represented by an average size (variances were included).

For comparison purposes, three barge sizes and six alternative methods of construction configurations were chosen:

1. Conventional single-skin construction used as the base vessel.
2. Single-skin with increased scantlings.
3. Single-skin with strengthening or redesign in selected areas.
4. Double-wall (sides and ends).

5. Double-hull (sides, ends, and bottom) construction.
6. Retrofit of existing single-skin conventional barges to suit 2 through 5 listed above.²⁷

The LCC of the barges with the various configurations is defined as (1) for new construction -- the cost of construction plus the discounted recurring costs minus the discounted salvage value; and (2) for retrofit -- the book value of the barge at the time of retrofit, plus the cost of the retrofit construction, plus the discounted recurring costs after retrofit, minus the discounted salvage value.

Each retrofit work is evaluated for 20 years, beginning at both the 12th and 18th years after initial construction. In addition to the "Retrofit Construction" classifications, a single-skin barge with no retrofit work being performed is considered in the analysis as the base for comparison purposes. Altogether, there are 57 particular barge analyses (5 new constructions and 14 retrofits for each of 3 sizes). The salvage value is calculated as a fixed percentage of the initial construction cost. Increases in weight due to retrofitting or "potential" new construction changes, i.e., single-skin to configuration X, are given in tables 6 and 7 of the study.

The recurring costs are limited to costs associated with hull insurance and a minimal repair and maintenance program. A questionnaire was sent to companies which own or operate tank barges in order to obtain recurring cost data. A computer program was written to determine LCCs in 1973 dollars, using discount rates of 5, 10, and 15 percent for the various tank barge configuration possibilities.

Table 10 of this study gives the life-cycle costs using engineering estimates for 6 sizes representative of the fleet using a 10 percent discount rate. From such tables, LCC differences can be calculated between configuration types and the incremental costs of the design alternatives can be estimated by comparing the LCC of the base vessels (without the design change) to the LCCs of the vessels with the alternative design changes incorporated either through new construction or retrofit. The discounted program costs for six combinations of policy were developed.

(Abbreviated)

1. Retrofit not required -- unrestricted new construction.
2. Retrofit not required -- double-hull (with trunk) new construction.
3. Retrofit not required -- double-wall (with trunk) new construction.
4. Double-hull (without trunk) retrofit -- double-hull (with trunk) new construction.

5. Double-wall (without trunk) retrofit -- double-wall (with trunk) new construction.
6. Double-wall (without trunk) retrofit -- double-hull (with trunk) new construction.

The model utilizes present value techniques to determine these discounted tank barge fleet program costs using a 25-year time horizon.

$$\text{Discounted program costs} = \sum_{n=1}^n \frac{1}{(1+r)^n} \sum_{i=1}^3 \sum_{j=1}^6 RF_{ijn} + (M \text{ and } R)_{ijn} + IN_{ijn} + Y_{ijn} \cdot I_{ijn} - Z_{ijn} \cdot S_{ij} \quad (16)$$

- i - index for configuration; $i=1$ represents single-skin; $i=2$ represents double-hull with trunk; $i=3$ represents double-wall with trunk
- j - index for one of six barge sizes
- n - index for year in the program
- r - discount rate
- RF_{ijn} - retrofitting costs from single-skin to double-hull or double-wall in year n
- $(M \text{ and } R)_{ijn}$ - maintenance and repair costs in year n
- IN_{ijn} - hull insurance costs in year n
- Y_{ijn} - number of barges of configuration i and size j added to fleet in year n
- I_{in} - construction cost of barges added to fleet in year n
- Z_{ijn} - number of barges of configuration i and size j retired from fleet in year n
- S_{ij} - salvage value of barges retired from fleet in year n
- $RF_{ijn} = CR_{ij} \cdot aT_{ijn}$
- CR_{ij} - cost of retrofit per barge retrofitted
- aT_{ijn} - number of barges retrofitted to double-hull or double-wall without trunk in year n
- $(M \text{ and } R)_{ijn} = \overline{MR}_{ij} \cdot X_{ijn} \quad (18)$
- \overline{MR}_{ij} - average annual maintenance and repair cost
- X_{ijn} - number of barges of configuration i and size j in year n
- $IN_{ijn} = \overline{IN}_{ij} \cdot X_{ij} \quad (19)$
- \overline{IN}_{ij} - average annual hull insurance cost

The assumptions made in establishing input variable values are listed below:
(Abbreviated)

1. Time length of program is 25 years. $n=1$ to 25.
2. Discount rate = r = 10 percent.
3. Barge retrofitting occurs by:

Barge Size

↓

Average Age

↓

4. The barge retrofitting program will be accomplished in 10 years.
5. Maintenance and repair and insurance costs are equal to 5 percent of new barge acquisition cost; these costs are to be applied to the number of tank barges of each size and configuration at year 12 in the 25-year program.
6. Given unrestricted selection of design configuration, a production preference of double-hull to single-skin barges is 55/45. This ratio may vary from year to year, but has been assumed to apply in each of the 25 years in policy 1.
7. A retirement program of 25 barges annually has been assumed (a fixed breakdown of retirement by size is given).
8. The salvage value is 10 percent of acquisition cost.³¹

Tables 13 through 18 of the study present undiscounted annual component costs and discounted program costs for each of the six policies. The basic format is:

Year	RF _{ijn}	X _{ijn} ($\overline{MR}_{ij} + \overline{IN}_{ij}$)	Y _{ijn} · I _{ij}	Z _{ijn}	ΣΣ	Discounted Program Costs ³²
↓	↓	↓	↓	↓	↓	↓

The survey of recurring costs is too limited for developing a complete methodology for measuring regulation costs. Little justification was given for the parameters chosen; therefore, the credibility of the LCC figures is questionable. Care must be taken when selecting the appropriate parameters and assumptions. Despite these problems, this methodology is applicable to other Coast Guard regulations given different fleet profiles, cost factors and data.

1.3 CONCLUDING REMARKS

Studies utilizing alternative cost estimating techniques (i.e., parametric costing and engineering costing) have been reviewed separately. At this point, it is useful to present the information contained in these reviews in a manner more directly applicable to the procedure development subtask. The life-cycle cost methodology will be utilized as the basis for illustrating the manner in which the alternative techniques can be applied to this subtask.

A life-cycle cost methodology can be viewed as the framework which aggregates different vessel cost components (e.g., initial and recurring costs) over the life of the vessel. Alternative cost estimating procedures can then be assessed in terms of their ability to estimate the incremental changes in the life-cycle cost components due to changes in Coast Guard regulations. Once the incremental change in a life-cycle cost component is known, the resultant impact on total life-cycle costs can be easily determined.

The cost estimating relationship utilized in section 1.2.1.1 (page 19) will be used to demonstrate this point. The equation will be left in its original form (i.e., aggregate costs of a single voyage) rather than converting it to the life-cycle cost form. As stated earlier, the conversion from one set of units to any other is easily handled by making reasonable vessel life-cycle assumptions (e.g., number of voyages per year, ship life time, appropriate discount rate, etc.).

As presented earlier, the aggregate costs of a single voyage can be expressed by the following equation:

$$C = C_f + C_l + C_k + C_m + C_b \quad (20)$$

where each of the cost variables are defined as follows:

- C = Total costs of a single voyage.
- C_f = Costs of fuel consumed on a single voyage, both at sea and in port.
- C_l = Labor costs at sea and in port including (a) the earnings of seamen, (b) supplements to earnings, such as contributions for social insurance and for welfare and pension plans, and (c) subsistence of the crew.
- C_k = The costs of the ship. These include (a) amortization of the initial construction costs of the ship, (b) insurance expenses, and (c) miscellaneous "other" vessel operating expenses.

C_m = The maintenance costs of the ship. These are the sum of repair and maintenance plus store expenses.

C_b = Port dues and charges. These are the costs for port taxes, pilotage, dockage, wharfage, anchorage, etc.

The cost of each component depends upon the physical properties of the ship, the specifications of the trade route, and the structure of factor prices. Each cost component equation will be treated in functional form, rather than specifying the actual cost equations used.

Of interest to our task is the change in the total costs of a single voyage due to a change in regulations. As specified, the proposed actions could affect:

- a. Vessel design criteria, including cargo size limits for specific cargoes, compartmentation criteria, and structural and stability requirements.
- b. Vessel equipment criteria, such as navigation or communication requirements or cargo control equipment.
- c. Vessel staffing and licensing criteria.
- d. Vessel inspection intervals and requirements.
- e. Any operational controls such as those resulting in delays (lengthening routes, reducing speeds, or requirements to delay port transit).

The effects on the total costs of a single voyage can be seen in the following mathematical representation. Taking the total differential of C with respect to action A_j (where j denotes a specific regulation).

$$\frac{dC}{dA_j} = \frac{dC_f}{dA_j} + \frac{dC_l}{dA_j} + \frac{dC_k}{dA_j} + \frac{dC_m}{dA_j} + \frac{dC_b}{dA_j}$$

The differentiation of C is only meaningful if at least one of its components is, in fact, a function of A_j . The cost estimating procedures of interest to this task are those that can provide estimates of the incremental changes in each of the cost components (e.g., $\frac{dC_f}{dA_j}$).

Conceptually, general cost estimating procedures such as parametric costing, engineering costing, analogy costing, and Delphi costing can be applied to this problem. The requirements of parametric costing procedures can be highlighted by the use of the cost component equations lying behind equation (20). (See page 31.) The explanatory

variables or parameters in the following equations should be viewed as only being indicative of those factors affecting costs.

$$\begin{aligned} C_b &= f_1(T, R, B) \\ C_f &= f_2(P_f, D, V, H, T) \\ C_l &= f_3(P_l, D, V, T, H) \\ C_k &= f_4(P_k, D, V, k_1, k_2, R, H) \\ C_m &= f_5(D, V, T, R, H) \end{aligned}$$

where:

- H - Shaft horsepower of the engine at normal cruising speed.
- R = Ship size as measured by the cubic number.
- V = Normal design speed in knots.
- B = Number of ports of call.
- D = The round voyage distance in nautical miles.
- T = Time in port days.
- K = Initial construction (or purchase) cost of the ship and $K = f_6(R, H)$.
- P_f = The price per pound of bunker "C" fuel oil, in dollars.
- P_l = The average daily wage per seaman including supplements and subsistence.

To evaluate the incremental costs of an action, A_j requires the specification of a change in the magnitude of one of the explanatory variables.

Mathematically.

$$\frac{dC_b}{dA_j} = \frac{df_1}{dA_j}(T, R, B)$$

Assuming the A_j increases the time in port, T , for the vessel type under consideration and that the functional relationship f_1 is not affected by A_j , then the change in C_b can be determined. However, as can be seen, the variable T also affects C_f and C_m requiring the evaluation of those cost components before the full change in costs can be determined.

To utilize existing cost estimating relationships as illustrated by the example above, requires that the following assumptions must be met:

- (1) The data utilized to determine the parameters of the equations are representative of current conditions.
- (2) The functional form of the equation must be the same (i.e., no major changes can be made in the basic physical configuration of the system to be estimated).
- (3) The explanatory variables utilized in the CERs must be of such detail as to be affected by a regulation change.

Engineering costing can also be applied to the estimation of the incremental component costs. This method consists of an aggregation of cost estimates from various separate work segments into a total project estimate. Providing data is available, engineering costing can be used wherever detailed cost estimates are desired. For example, the Maritime Administration estimates the costs of commercial vessels by (1) breaking a ship down into three components: steel, outfit, and machinery; (2) measuring the labor, material and overhead costs utilized within each of the components; and (3) consolidating the costs for each of the components, and then combining these component costs to estimate the ship's total cost.

Engineering estimates have been used in the past to measure the costs of Coast Guard regulations. In addition, the Coast Guard, the American Petroleum Institute, and the Maritime Administration have directly applied engineering costing techniques to determine the costs of specific regulations involving changes in vessel design.

The benefits of engineering costing lies in its functional simplicity and general applicability. However, it suffers from the fundamental problem of data reliability and has no predictive capabilities, therefore an original factor cost estimate would be required each time a regulation is analyzed.

Analogy and Delphi costing techniques can also be applied to estimating the costs of a regulation. Analogy costing effectively draws an analogy between characteristics of a system with known costs and the system under consideration. Once the analogy has been determined, the costs of the specific system can be estimated. The limitation of analogy costing lies in its critical dependency upon the analyst's ability to formulate accurately the required analogy between the characteristics of the systems under consideration.

Delphi costing, based upon expert opinion, is another estimating technique that is usually applied to cases where historical data do not exist or are unavailable. The precision of this technique is highly dependent upon the group of experts composing the

panel and the manner in which the exercises are conducted. Because of the need to assemble a panel of experts each time the costs of a proposed regulation (or set of proposed regulations) are to be determined, the Delphi method appears to be less applicable to the problem at hand. Both analogy costing and Delphi costing will be considered as alternative estimating techniques if parametric or engineering cost techniques cannot be applied.

As mentioned above, costing techniques depend upon obtaining current data in the appropriate formats. In most cases, the data necessary to estimate the costs of proposed regulations can be obtained from experienced cost estimators at the Maritime Administration; the U.S. Navy; the U.S. Coast Guard; unions of the Merchant Marine; commercial shipyards and ship owners; and equipment manufacturers.

PART 1. ENDNOTES

1. U.S. Coast Guard, Marine Safety Manual, CG-495, Volume I (Washington, D.C.: U.S. Government Printing Office, 1977).
2. U.S. Coast Guard, Operating Program Plan for Commercial Vessel Safety (1977).
3. U.S. Coast Guard, Marine Inspection Offices Workload and Billet Distribution Study (1974).
4. Ibid., p. 3.
5. Ibid., p. 4.
6. Ibid., p. 56.
7. U.S. Coast Guard, Commandant Notice 7100, April 1977. Subject: Annual Standard Personnel.
8. U.S. Coast Guard, Enclosure to COMDTINST 16465.2A, November 1976. Subject: Standard Rates.
9. Maritime Administration, Handbook for Life Cycle Cost Analysis (October 1970).
10. Walter Y. Oi, "The Cost of Ocean Shipping," in Allen R. Ferguson, et al, The Economic Value of the U.S. Merchant Marine (Evanston, Illinois: The Transportation Center at Northwestern University, 1961), pp. 107-165.
11. Ibid., p. 3.
12. Ibid., p. 111.
13. Ibid.
14. Ibid., pp. 499-508.
15. Ibid., p. 113.
16. Ibid., p. 132.
17. E. G. Frankel and H. S. Marcus, Ocean Transportation (Cambridge, Massachusetts: The MIT press. 1973).
18. Ibid., p. 607.
19. Ibid., p. 664.
20. Ibid., p. 647.
21. Ibid.

22. Harry Benford, General Cargo Ship Economics and Design (Ann Arbor, Michigan: University of Michigan, 1965).
23. Ibid., p. 1.
24. Ibid., pp. 71-72.
25. Maritime Administration, Joint Maritime Administration/Coast Guard Tank Barge Study (Washington, D.C., 1974).
26. Ibid., p. 2.
27. Ibid., p. 63.
28. Ibid., p. 70.
29. Ibid., p. 83.
30. Ibid., p. 89.
31. Ibid., p. 91.
32. Ibid., p. 94.

2. DETERMINATION OF THE COST IMPACTS OF PROPOSED COAST GUARD REGULATIONS

PRC/Systems Services Company is developing a methodology which can be used to determine the impacts of the estimated costs of Coast Guard regulations and their enforcement. As a first step, PRC/Systems Services Company has reviewed methodologies which have been used in the past to answer similar questions and which give the most promise of being applicable for the present study. These methodologies can be separated into two broad classes. Microeconomic studies assess the impacts of regulation costs on output, prices, employment, and profits in the regulated industry with some attention given to effects in important related industries. Macroeconomic studies use some of the information generated from a microeconomic study to determine the impacts of regulation costs on economy-wide variables including the general price level, gross national product, national unemployment, and the trade balance. The difference between the two methodology classes lies in their scope: microeconomic studies focus on impacts in specific industries while macroeconomic studies focus on impacts in the economy as a whole.

This survey discusses the relative merits of microeconomic industry analysis and macroeconomic analysis for determining the impacts of Coast Guard regulation costs. Specific applications which deal with problems similar to the one at hand are reviewed and their methodologies are discussed with regard to inherent advantages, disadvantages, and applicability to the U.S. maritime industry.

2.1 MICROECONOMIC ANALYSIS

This section describes the microeconomic methodologies employed in three representative studies of industry effects of regulations.

2.1.1 The Economic Impact of Pollution Control¹

Microeconomic studies of the impacts of the costs of air and water pollution abatement regulations in 13 industries for 1972 to 1976 were prepared for the Environmental Protection Agency (EPA) in 1972. The studies concentrate on the changes in sales, prices, profits, and employment expected to result from pollution control expenditures in the industries studied. Limited discussions of adverse effects in related (customer, supplier, competing) industries and in individual communities and regions are also included. Each industry was studied by a different contractor. Consequently, the studies differ in presentation and in depth and quality of analysis. However, they all employ the same basic methodology which is tailored to fit the specifics of each industry studied.

These studies can be criticized individually in terms of economic analysis, completeness, data sources, estimation techniques, and assumptions. However, the purpose of this survey is not so much to criticize the individual applications as it is to assess the value of different methodologies for determining the impacts of Coast Guard regulation costs. The general methodology used in the EPA studies is described and criticized, instead of the individual industry studies which employ the methodology.

Briefly, the methodology consists of two steps: (1) characterize the supply and demand conditions and past performance of the industry; and (2) given these conditions, determine the effect a change in production costs, due to a regulation, will have on elements of industry performance. The basic framework of the methodology is described in more detail below.

- Define the industry in terms of product(s) produced and/or types of firms or processes to be included in the study.
- Describe or estimate the demand and market characteristics of the industry. The most important characteristics in this category include:
 - a. The size, location, and relative importance of markets for the industry's product and per capita consumption of the product.
 - b. The number of domestic and foreign substitutes for the product.
 - c. The number of complementary products, i.e., other products generally bought or used with the product of the subject industry.
 - d. Demand elasticity. Demand elasticity describes the relationship between the price of a product and the quantity demanded. It is defined as the percent change in quantity demanded per percent change in product price. When demand is elastic, a 1 percent increase in product price leads to a greater than 1 percent decrease in quantity demanded. When demand is inelastic, a 1 percent increase in product price leads to a less than 1 percent decrease in quantity demanded. Roughly, demand will be more inelastic if the number of substitutes to the product is small, the number of complements is large, and the price of the product is only a small part of the buyer's budget. Estimate of demand elasticity can be obtained through the use of historical data on price changes and corresponding changes in quantity demanded.
 - e. Trends in demand. This involves reviewing how demand has changed in the past and projecting its growth or decline in the future as a function of changes in population, national income, the prices of substitutes and complements, and technology.

- Describe the industry structure and supply characteristics of the industry. Important elements in this category include:
 - a. Number and relative sizes of plants and firms in the industry.
 - b. Concentration of the industry and market share of individual firms in the industry based on the number and sizes of firms in the industry.
 - c. Barriers to entry including economies of scale and government regulations.
 - d. Ownership characteristics of the industry.
 - e. Diversification and vertical and horizontal integration in the industry.
 - f. Total employment in the industry and skill level of labor.
 - g. Production processes and costs of production.
 - h. Financial practices, including ratio of debt to equity and ease of getting capital.
 - i. Age of existing plants and average operating life of plants.
 - j. Expected trends in supply characteristics and industry structure in the absence of pollution control expenditures.
- Describe the past and present market performance of the industry. Important elements of industry performance include:
 - a. The price of the product.
 - b. Total sales.
 - c. The pricing mechanism, e.g., competitive market forces, price leadership, collusion or other monopolistic practices, or government regulation.
 - d. Industry profits. Profits are a function of price, output, production costs, and extent of competition in the subject industry.
- Describe expected trends in industry performance in the absence of pollution abatement expenditures.
- Describe pollution control costs as a percent of total sales. This is used as a method of determining the relative magnitude or importance of the costs.
- Estimate the impact of these cost increases on the price of the product. The ability of the industry or firms in the industry to pass the increased costs onto buyers of the product in the form of price increases is a function of elasticity of demand and market power.
- Determine the impact of the estimated price increases on the output of the industry and on profits in the industry.

- Given the estimated price, output, and profit changes, determine the plants that can be expected to close as a result of these changes. Such plant closings will be a function of plant size and age, plant profitability, and the ability of plants to obtain financing for the pollution control investments.
- Determine the short-run employment changes which will be associated with the estimated output changes and plant closings.
- Determine the long-run employment changes as a function of skill level and other determinants of labor mobility.
- Describe the local or regional impacts by determining the location of plants which can be expected to close. This generally takes the form of describing if the plants are located in economically depressed areas, in which case it is assumed that the plant closings will aggravate the situation.
- Describe the expected effects of the price and output changes on supplier, buyer, and competing foreign and domestic industries. This generally takes the form of a verbal description of impacts based on a limited analysis of these related industries.

As noted above, this basic methodology was employed in each of the 13 industry studies. The theories of industrial organization, on which this methodology is built, are well defined in economic literature and practice. In the broad sense, economic theory states once an industry has been defined and its structure or supply and demand conditions described in certain ways, future industry performance can be predicted on the basis of this structure and on past performance. The importance of different elements of market conditions and the relationships between these elements and industry performance have been extensively tested in the literature.² The methodology used in the EPA studies applies this knowledge of industrial organization and microeconomics to estimate, or, at least, describe the adverse effects an increase in production costs (due to pollution control expenditures) will have on industry performance. Depending on types and availability of data, magnitude of cost increases and estimation techniques, the results are qualitative or quantitative in nature.

The results of these microeconomic studies indicate that, while the long-run viability of no industry is seriously threatened, profits will decline in some firms in the industries as a result of the pollution abatement costs. This occurs because the costs cannot be passed on entirely to consumers in the form of price increases, either because of the availability of substitutes or foreign produced products or because price increases in smaller firms with higher average abatement costs are constrained by larger firms with lower average abatement costs. The studies identify those firms that will earn the lower

profits, that must curtail production, or that will be forced to close. From the studies, most of the firms forced to close are already marginal operations and, thus, the effect of the pollution abatement requirements is to accelerate the closing of smaller, older, and less efficient producers.

The studies measure the direct and indirect impacts of the decline in production and firm closings. The most important direct impact is the loss of jobs. Important indirect impacts are effects on customer and supplier firms forced to curtail production or shut down and effects on communities and regions which may suffer because of production slow-downs or plant closings.

The methodology used in the EPA studies contains several shortcomings. First, it does not address possible positive effects of the pollution control expenditures. Examples include increased profits and employment in industries which produce the pollution control equipment; increased profits in firms which absorb the market share of firms which close because of the controls; productivity increases when the regulations stimulate technical innovation; or, average productivity increases as inefficient firms shut down.

Second, it provides no rule to determine when effects on related industries are significant enough to warrant study. Because of the interrelationships of our economy, cost changes in one industry will affect, indirectly, all or most of the other industries. In most microeconomic analyses, however, time and other resource constraints dictate that the industries studied must be limited to those which experience significant impacts. The EPA methodology provides no guidelines for determining which related industries are important enough to include in the analysis or what constitutes a significant impact.

Third, the methodology contains no explicit guidance regarding how large regulation costs must be before they will have discernable impacts. Instead, it seems that each contractor decided, more or less on an intuitive basis, if the costs were large enough to require a detailed study of their impacts.

On the plus side, this methodology is useful because of its flexibility. This is evidenced by the wide variety of industries analyzed in the EPA reports. Included, for example, are consumer product industries (automobiles); intermediate industries (fruit and vegetable canning); raw material industries (iron foundries); energy industries (petroleum refining); and extremely regulated industries (electric power generators). In addition, the methodology can be adjusted to the data available in the industry under study. When a large quantity of data are available regarding demand and supply conditions, market and industry structure, pricing procedures, market power, and other measures of past performance, the impacts of the regulations can be quantitatively measured. Conversely, when data are not available, the impacts of the regulation can be presented in a descriptive or qualitative fashion.

Because of the flexibility of the methodology, it can be adjusted to measure the direct impacts of Coast Guard regulations for hazardous material carriers on the maritime industry and the indirect impacts of those regulations on related industries (e.g., shipbuilding or oil and liquefied natural gas companies) and communities (e.g., those surrounding ports). The difficulty involved in making these adjustments depends on the complexity of the maritime industry and on the breadth and depth of the impact analysis undertaken.

2.1.2 Study of the Potential Economic Impacts of the Proposed Toxic Substances Control Act³

The main provisions of the Toxic Substances Control Act call for increased testing and reporting in the premarket screening of new and existing chemical substances. Foster D. Snell, Inc., has assessed the potential impacts of these requirements on the chemical industry. The methodology used to determine these impacts is described below.

- Define the industry in terms of product(s) produced and types of firms or processes to be included in the study.
- Describe the industry structure and supply characteristics of the industry. Important elements in this category include:
 - a. Number, relative size, and geographical distribution of firms in the industry.
 - b. Total employment in the industry, as well as employment in individual firms.
 - c. Costs of production.
 - d. Financial practices including debt to equity ratio.
- Describe the past and present market performance of the industry. Important elements of industry performance include:
 - a. Total sales.
 - b. Industry profits.
 - c. Productivity.
 - d. Research and development in the industry as a whole and per firm size.
 - e. Rates of new product innovation in the industry as a whole and per firm size.
- Estimate the direct incremental costs of compliance with the regulation. Snell estimated these costs through the use of an industry-wide survey.

- Calculate the changes in industry performance which will result from these costs. To do this, Snell again resorted to an industry-wide survey. Important elements of performance the study included are:
 - a. Changes in research and development in the industry as a whole and per firm size.
 - b. Changes in rates of new product innovation in the industry as a whole and per firm size.
 - c. Estimated plant or firm closings as a function of their ability to comply with the regulation.
- Describe the effects of the regulation on supplier industries. Snell limited its study to the effects on the toxicology industry. This industry supplies the laboratories in which much of the new testing required by the Control Act would be done. Snell concentrated on determining the industry's capacity and ability to absorb increases in demand.

The above methodology rests, essentially, on the same basic economic theory as does the methodology employed in the EPA studies. That is, given industry supply and demand conditions and past performance, industry performance in the face of a cost increase can be predicted. The methodology limits its analysis of industry performance to the rate of new product innovation and the level of research and development funding. It ignores the impacts on other elements of industry performance, e.g., profits, sales, or employment which might result from the control act. It also ignores elements of industry structure, e.g., demand characteristics which do not relate directly to innovation or research and development.

Because of its emphasis on innovation and research and development, the Snell methodology is not easily adaptable to industries that differ fundamentally from the chemical industry. Unless an industry is extremely research intensive, application of the Snell methodology would miss many important impacts of regulation costs.

With respect to related industries, the Snell methodology, like the EPA methodologies, sheds no light on when a related industry should be studied. The toxicology industry is, perhaps, the most relevant input industry affected by the act, but there are other industries which will be affected. The methodology contains no rationale as to why they were not analyzed. For example, Snell reports the basic chemical industry consumes almost 20 percent of manufacturing energy for heat and power. This statistic suggests a contraction of the chemical industry might have significant effects on energy industries; however, no analysis was done.

Overall, the Snell methodology only partially enables the impacts of regulation costs on industry performance to be assessed. The methodology does indicate how the regulations of the type under study may affect the rate of innovation in an industry. Innovation is often included as an element of industry performance in industrial organization studies and theories exist concerning the relationship between industry structure and innovation.⁴ The Snell methodology suggests that innovation should not be ignored as an element of industry performance.

2.1.3 Hazardous Wastes: A Risk-Benefit Framework⁵

Stanford Research Institute (SRI), under contract to the Environmental Protection Agency, has developed a methodology for assessing the costs and benefits of environmental standards of hazardous waste disposal. On the cost side, their methodology addressed not only the estimation of the costs of pollution abatement regulations, but also the assessment of the impacts or "ultimate economic effects" of these costs. It is this latter part of their cost methodology which is relevant for our survey.

This cost impact methodology is interesting because it includes an analysis of the loss of consumer surplus resulting from the pollution abatement costs and an analysis of the beneficial effects of pollution control expenditures (for example, in industries that produce control equipment). To illustrate their methodology, SRI looked at several different methods to decrease cadmium and asbestos emissions. In analyzing their methodology, only the impact on the zinc industry of the costs of installing limestone scrubbers to reduce the cadmium emissions of zinc smelters were considered. The general steps involved in applying their methodology are described below:

- Define the industry in terms of product(s) produced and types of processes to be included in the study.
- Describe or estimate the demand characteristics of the industry. The important elements in this category are:
 - a. The number of domestic and foreign substitutes of the product.
 - b. Demand elasticity.
 - c. Trends in demand.
- Describe the industry structure and supply characteristics of the industry. Important elements to include are:
 - a. Supply elasticity.
 - b. Trends in supply.
 - c. Production processes and costs of production.
 - d. Total employment and total wage bill.

- Describe the past and present market performance of the industry including:
 - a. Price of the product.
 - b. Total sales.
 - c. Value of production defined as the price times total output produced.
 - d. Industry profits.
- Estimate the increase in price, decrease in output, and corresponding change in profits which will result from the regulation costs. SRI based their estimates on the analysis of industry structure.
- Determine the loss of consumers' surplus that will result from these changes in prices and output. Consumers' surplus is used as an index of consumer satisfaction or welfare. It is defined as the maximum amount consumers are willing to pay for a given quantity of the good, less the amount they actually have to pay (i.e., the market price).

Figure 2 shows the concept of consumers' surplus graphically. Consumers' surplus is measured by the area of the upper left-hand triangle.

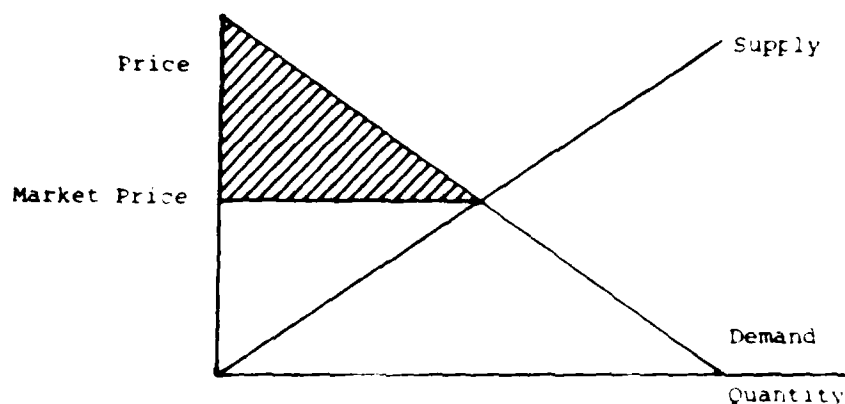


Figure 2 Consumers' Surplus

When the supply curve shifts upward because of increased production costs, consumers' surplus is diminished, *ceteris paribus*. Given estimates of supply and demand and the shift in supply which will result from the regulation costs, this decrease in consumers' surplus can be estimated.

- Determine the net employment effects of the regulations. SRI estimates these employment effects by "(1) associating with the loss of zinc production a proportionate loss of employment; (2) associating with the costs of using and maintaining control equipment, a proportionate gain in employment; and (3) associating with the increased sale of control equipment, a proportionate gain in employment."⁶
- Determine the short- and long-run regional effects of the increased costs in the regulated industry. These regional effects are assumed to be a function of the net reduction of employment in areas where the regulated industry and the control equipment industry are concentrated. SRI limited its regional analysis to employment effects for two reasons. One, they assumed the consumer effects of the price and output changes as measured by the loss in consumers' surplus would be widely distributed over the population because of the widespread use of zinc and zinc products. Two, they assumed that profits effects would not show significant geographic patterns because of the widespread distribution of absentee and publicly-held owners.
- Determine the effects of the regulation on prices, profits, and output in substitute markets, especially foreign supply markets.

One shortcoming of this methodology is its concentration on the effects in the zinc industry as a whole and its neglect of effects on firms in the industry. For example, the reader gets little information concerning the number and sizes of firms in the industry, who owns them, or which ones are the marginal operations. Similarly, there is little presented on the markets for and consumption of zinc and zinc products. Another shortcoming is that it contains little guidance concerning which related industries should be studied. It should be pointed out SRI does emphasize related industries that gain because of the regulation costs.

On the plus side, SRI is distinctive for its analysis of the loss of consumers' surplus. Consumers' surplus is not a measure of industry performance in the way profits, employment, or innovation are. Because it is a measure of consumer satisfaction, certain consumer effects of the costs of a regulation can be estimated by measuring the change in consumers' surplus resulting from those costs. It should be noted that part of the loss of consumers' surplus is transferred to producers.

While there are significant differences in the three microeconomic methodologies which have been discussed, the basic similarity is readily apparent. They are all based on the same economic theory which is stated explicitly in the SRI study: "To anticipate the effects of controls, analysis is required of the structure of the zinc industry and the probable behavior of the domestic producers."⁷

The methodologies differ in their applications of this theory in two basic ways: first, in their discussion and depth of analysis of demand and supply conditions; and, second, in the elements of industry performance they analyze for regulation cost effects. Some of these differences arise because the methodologies are tailored to fit the individual industries under study. Other differences are the result of poor data, different priorities, and incompleteness.

Whatever the reasons, the relevant question for the present study is to decide the appropriate level of detail of the supply and demand analysis and, more importantly, the elements of industry performance which should be analyzed for effects due to Coast Guard regulations costs. Once these questions have been addressed, the analyst can tailor a methodology for the maritime industry from these three methodologies and from theories of microeconomics and industrial organization. In order to accomplish this, it is necessary to understand the specific elements of the maritime industry which make it unique.

2.2 MACROECONOMIC ANALYSIS

A macroeconomic analysis changes the scope of impact studies from effects on selected industries to effects on all industries and on certain economy-wide variables. As mentioned previously, macroeconomic studies of the effects of pollution control expenditures use some of the information generated from microeconomic analysis to determine the impacts of the expenditures on the general price level, gross national product (GNP), national unemployment, and the balance of trade.

Each of the three studies we have discussed within the context of microeconomic analysis also include methodologies for assessing the macroeconomic impacts of their respective regulations. These methodologies will be reviewed in turn.

2.2.1 The Economic Impact of Pollution Control

In addition to the 13 microeconomic industry studies performed for EPA in 1972, Chase Econometric Associates performed a macroeconomic study of the effects of the sum of the costs of pollution control regulations imposed on the 13 industries.⁸ This study was updated in 1975 to extend the impact analysis up to 1982.⁹ The same methodology was used in both editions and is summarized below.

- Define the annual operation and maintenance costs of these pollution control investments as an increase in each industry's production costs. The costs were estimated by EPA and the Council on Environmental Quality (CEQ).
- Determine the extent of forward shifting of these production cost increases. To do this, the authors calculated "markup" factors, the proportion of additional costs passed along as higher prices, as a function of supply and demand conditions in each industry. The industry markup factors ranged from 0.8 to 1.0.
- Given these estimated price increases, trace the interindustry effects through to price changes of final consumption goods and services. To do this, the Chase study used the input/output matrix of the United States economy developed by the Bureau of Economic Analysis of the U.S. Department of Commerce. The coefficients of this matrix are measures of the amount of a given product needed to produce another product.
- Adjust investment demand to reflect the increases in investment which will result from expenditures on pollution abatement equipment.
- Calculate the equilibrium changes in price indices, the unemployment rate, GNP, and the balance of trade in the test years which will result from these

increases in the prices of consumer products and in investment demand. To do this, Chase used the Interindustry Forecasting Model of the American Economy (INFORUM) developed by the University of Maryland.¹⁰ INFORUM is a computer-based econometric model which forecasts the equilibrium levels of prices, output, employment, net exports, and other variables, both for the economy as a whole and for the economy divided into sectors given certain assumptions regarding final demand. In order to determine the magnitude of the effects of the pollution control expenditures, Chase first used INFORUM to project a base forecast of the economy in the absence of pollution control expenditures. Next, Chase used INFORUM to project a forecast given the increases in prices and investment demand resulting from the pollution control expenditures. Comparison of the base forecast to the latter forecast provides the means for determining the macroeconomic impacts of the regulations.

- Calculate the equilibrium changes on prices, output, and employment in the industrial sectors from the pollution control expenditures. This, too, is done by the INFORUM model and is essentially a by-product of the preceding step because INFORUM divides the economy into industrial sectors in order to do its forecasting.

The results of the macroeconomic study indicates the economy will be significantly, but not severely, impacted by the regulations. The dynamics of the impacts are as follows: The control costs are assumed to affect the economy by raising prices and increasing industry demand for investments in control equipment. On the one hand, the higher prices, in the absence of offsetting government policies, tend to slow the growth of demand in the economy. On the other hand, investments in equipment boost demand and, thereby, generate output and employment. This stimulating effect is outweighed by the contrasting effect of the price rises resulting in a net decrease in GNP growth.

The major shortcoming of this methodology is the fact the results depend heavily on the assumptions made. For example, to use INFORUM, or any economic forecasting model, assumptions must be made concerning future population size, labor force size, interest rates, government policies, and relative international prices. In addition, the first order impacts of the regulation must be put into terms compatible with INFORUM. Thus, Chase assumed the pollution abatement regulations result only in increases in prices and investment demand, but changes in government spending, taxes, or import demand may also result.

To reiterate, the results emerging from the use of any methodology are only as good as the assumptions made and the data used. The Chase methodology involves a large number of assumptions. This problem can be partially overcome by running the model with different assumptions to get a range of possible impacts. Chase did this; they projected two forecasts based on different assumptions regarding government policies. They also ran the model with three alternative levels of pollution control costs in an attempt to correct for inaccuracies in the cost estimates.

The applicability of this methodology for the problem at hand centers on the magnitude of the costs of the Coast Guard regulations. The Chase methodology can be used satisfactorily only when regulation costs are large. The methodology, however, does not define "large." Examining some of the costs and impacts measured in the Chase study may provide some insight.

The costs of the pollution abatement requirements for 1973 to 1977 were estimated at \$44.9 billion in investment costs and \$33.0 billion in annual costs which include depreciation, interest charges, and operating and maintenance expenditures. For 1978 to 1982, investment costs were estimated at \$2.1 billion and annual costs at \$48.9 billion. The largest price effect of these costs was estimated to occur in 1976 when the GNP deflator was projected to rise 0.9 percent more than the base forecast, with the wholesale price index rising an additional 1.9 percent. The greatest decrement in growth of real GNP is projected to occur in 1979 when GNP is 2.0 percent below the base forecast.

The fact that these massive cost increases result in such relatively minor impacts suggests much smaller cost increases would result in impacts which would either be unmeasurable or which would be less than the margin of error built into the methodology. This margin of error is not made explicit by Chase. Consequently, we have only an intuitive idea regarding the magnitude of costs which would result in discernable or statistically valid impacts.

2.2.2 Study of the Potential Economic Impacts of the Proposed Toxic Substances Control Act

The Snell macroeconomic methodology, like the Chase methodology, uses the INFORUM model to assess the macroeconomic impacts of the Control Act for 1976 to 1985. Despite this similarity, there are significant differences between the Chase and the Snell methodologies. The most significant differences arise from the way the Snell study handles price changes and from the study concentrating on cost increases for only one industry (the chemical industry) rather than many. The methodology is summarized below.

- Describe the historical role of the industry in the economy. The purpose of this step is to point out the relative importance of the industry to the economy as a whole. To illustrate, Snell noted that the chemical industry from 1950 to 1975 accounted for 6 percent of total GNP, 2 percent of national income, and 5 percent of manufacturing employment. Snell also noted the positive value of the chemical trade balance increased by 50 percent during that period.
- Using the INFORUM model, develop a base forecast of the economy for 1972 to 1985 in the absence of the Control Act. Comparison of the levels of prices, unemployment, GNP, and exports and imports from the base forecast to those emerging from the analysis with the costs of compliance factored in, provides the means for determining the macroeconomic impacts of the Control Act.
- Develop alternative scenarios which provide an upper and lower boundary to the increases in price that can be expected to result from the cost increases.

The two scenarios developed are named "maintenance of innovation" and "displacement of innovation." In maintenance of innovation it is assumed that the industry will maintain historical levels of innovation by passing on the costs of compliance in the form of price increases. Thus, under this scenario, prices are assumed to increase by the full amount of the cost increases. In displacement of innovation it is assumed the industry will finance the costs of compliance by earmarking a portion of its research and development budget for this. Thus, under this scenario, it is assumed chemical prices will not increase; instead, the rate of innovation will decrease.

- Define the costs of compliance as an increase in the industry's production costs. These costs were estimated from industry surveys for two levels of testing: low level and extensive. The macroeconomic impacts of both levels were estimated.
- Given the assumption of complete pass-through to consumers of the costs of compliance (maintenance of innovation scenario), determine the increase in chemical prices associated with these costs.
- Given these price increases, trace the interindustry effects through to price changes of final consumption goods and services. To do this, Snell used the input/output matrix of the U.S. economy developed by the Bureau of Economic Analysis and updated in the INFORUM model.

- Adjust investment demand to reflect the increases in investment due to expenditures on plant and equipment in compliance with the Control Act. Adjust government spending to reflect the costs of administering and enforcing the Control Act. Adjust import demand to reflect the increase in import prices caused by foreign compliance with the act.
- Using INFORUM, calculate the equilibrium changes in price indices, the unemployment rate, GNP, and the trade balance due to these estimated changes in prices of consumer products, government spending, investment, and import demand. These estimates provide an upper bound to the impacts of the costs of compliance on the macroeconomic indicators.
- Given the second assumption of no change in chemical prices (displacement of innovation scenario), determine the effect the reduction in the generation of new chemical products will have, over time, on the technical coefficients of the input/output matrix.¹¹ It is assumed the predominant element in coefficient change over time is the substitution of new chemicals for tasks performed by existing chemicals. The original coefficients were estimated given an expected level of new product development in these test years. The level of new product development, under this scenario, has decreased because of the Control Act. The coefficients must change to reflect this decrease.
- Adjust government spending, investment in plant and equipment, and import demand to reflect the compliance with and administration of the Control Act.
- Given the new projections of the input/output coefficients and the changes in investment, government spending, and import demand, rerun the INFORUM model to calculate the equilibrium changes in price indices, GNP, unemployment, and the trade balance. These estimates provide a lower bound to the impacts of the costs of compliance on the macroeconomic indicators.
- Using the INFORUM model, calculate the equilibrium changes in prices, employment, and output in the six industrial sectors contained in the input/output model which make up the chemical industry. Calculate these changes under both scenarios or price assumptions so an upper and lower boundary on impacts will result.

Because of the similarities between the two methodologies, many of the shortcomings of the Chase methodology are also found in the Snell methodology. Due to the

use of a macroeconomic model of the economy (INFORUM), the results of the analysis depend heavily on the assumptions made concerning the absolute size of the economy. Similarly, the first order impacts of the regulation must be put into terms compatible with INFORUM. Snell makes two assumptions regarding the effect of the Control Act on prices: first, prices will rise by the full amount of the cost increases, and second, prices will be unaffected by the increased costs. The effect of these two assumptions was to provide an upper and lower bound to the macroeconomic impacts of the Control Act.

Snell also assumed the Control Act would lead to an increase in investment demand as firms buy the necessary equipment; an increase in government spending due to the administration of the Control Act; and an increase in import prices given the foreign suppliers would also be required to comply with the Control Act.

Given these assumptions, in addition to the two alternative price assumptions, the logic of the model is to determine the net effect of these offsetting changes, both for the economy as a whole and for the chemical industry. The results of the analysis were as follows. Under the maintenance of innovation scenario (prices increase to cover costs), the estimated \$1.3 billion costs result in a 20,000 increase in unemployed persons; a 1 percent decrease in real GNP; an increase of 0.9 in the wholesale price index; a \$1.1 billion decrease in the trade balance; and a \$0.8 billion increase in sales of the chemical industry. Under the displacement of innovation scenario (no price increases), the \$600 million costs¹² result in an 80,000 increase in unemployed persons; a .02 percent decrease in real GNP; no impact on the wholesale price index; a \$220 million decrease in the trade balance; and a \$2.5 billion decrease in domestic chemical sales.

The estimated costs of the Toxic Substances Control Act are closer to the order of magnitude of the proposed Coast Guard regulations. The Snell methodology does not contain any guidance concerning how large costs must be before the INFORUM model will produce reasonably accurate and statistically valid estimates.

2.2.3 Hazardous Wastes: A Risk-Benefit Framework

The macroeconomic methodology used in the SRI study does not employ an input/output matrix or a forecasting model of the economy. Instead, by making certain assumptions, it translates individual industry impacts directly into economy-wide impacts. The methodology they use to determine national effects is summarized below.

- Determine the extra amount consumers must pay for products which contain the regulated product as an input. In the zinc example, SRI measured this reduction by aggregating the change in the value of domestic zinc production and the change in the value of foreign zinc production. If the

regulation costs lead to a \$28 million increase in zinc imports and a \$21 million decrease in domestic zinc production, then consumers are paying \$7 million more for zinc products.

- Determine the effect of the regulation costs on GNP. To do this, SRI assumes the change in GNP is equal to the net change in the value of domestic production in the industries directly affected by the regulation plus the change in consumer purchasing power. In SRI's illustration, the value of production in the domestic zinc industry decreased by \$21 million. In addition, consumers are paying \$7 million more for products which contain zinc. These decreases are offset, in part, by a \$4 million increase in the value of cadmium production (because the scrubbers capture cadmium which can be marketed) and a \$3 million increase in the value of production of control equipment. Aggregating these changes, the net effect on value of production is a decrease of \$21 million. This \$21 million decrease is assumed to approximate the effect on GNP of the regulation costs.
- Determine the effect on federal tax receipts. To do this, SRI assumes this effect will come entirely from a decrease in federal corporate profits tax resulting from the reduction in profits caused by the regulation.
- Determine the effects of the regulation on the balance of trade. These effects depend on (1) the extent of foreign competition for sales of the product; (2) whether the controls are also imposed on the countries supplying the product to the U.S.; and (3) any changes in import quotas or tariffs resulting from the regulation. To measure the balance of trade effects, SRI assumes an increase in the value of imports by a certain amount decreases the overall balance of trade by that same amount.
- Determine the national employment effects of the regulation. To do this, SRI assumes the national employment effects can be approximated by the employment effects in the directly impacted industries. In the zinc example, SRI aggregated the employment changes in the zinc, cadmium, and control equipment industries. This net employment change was augmented by a multiplier of two in an attempt to capture some of the national ripple effects resulting from the local employment changes.
- Determine the national effect of the regulation on investment funds. The change in investment funds is assumed to equal the change in gross profits after taxes in the directly affected industries. To illustrate, SRI estimated total profits in the zinc, cadmium, and control equipment industries will

decrease by \$19 million per year due to the costs of regulation. As a result, corporate profit taxes will decrease by \$10 million per year. Thus, funds available for investment are assumed to decrease by \$9 million per year.

The difference in the focus of this methodology, when compared to the Chase and Snell methodologies, is readily apparent. In simple terms, the SRI methodology aggregates the effects of controls on certain variables in only the industries directly affected (i.e., the zinc, cadmium, and control equipment industries) and calls these the national effects. By doing this, they are implicitly assuming that the effects in these industries will have minimum indirect effects in other industries. This can be contrasted to the Chase and Snell methodologies which explicitly recognize the interdependence of our economy. These studies use a macroeconomic model of our economy to forecast the equilibrium levels of price, unemployment, GNP, and the trade balance which will prevail in the economy as a whole and by industry sector in the absence of the regulations. The preregulation equilibrium values are compared to the new equilibrium values which the model forecasts after the costs of the regulation have been factored in. By doing this, it is acknowledged that a change in any industry, ceteris paribus, pushes the economy out of equilibrium and will lead to changes in all other industries and in economy-wide indicators as the economy moves to a new equilibrium.

The SRI methodology, even though it neglects the interrelationships of our economy, is still a valuable methodology for assessing the macroeconomic effects of regulation costs. The very restrictive assumptions which must be made are a shortcoming of this methodology. This shortcoming is offset by the fact that the magnitude of costs involved is not an important consideration with this methodology. The national impacts are measurable as long as the effects on profits, employment, imports, and sales in the directly-affected industries are measurable at the micro level. The Chase and Snell methodologies, in contrast, can only be used satisfactorily when regulation costs are large enough to produce statistically significant changes in the macroeconomic indicators.

The discussion so far has centered around three studies which contain methodologies to assess both the macroeconomic and microeconomic impacts of regulations under study. Each of the six methodologies reviewed could be adapted to fit the costs of Coast Guard regulations of hazardous material carriers. Moreover, they could be used to assess the impacts of such costs on the economy as a whole, on the maritime industry, and on its important customer, supplier, and competing industries. In order to determine which methodology or combination of methodologies is appropriate, an understanding of the complexities of the maritime industry is necessary. The next section contains an overview of the maritime industry.

2.3 THE MARITIME INDUSTRY OVERVIEW

No matter which methodology is chosen for assessing the costs of Coast Guard regulations, it would involve some analysis of the demand and supply conditions and past performance of the maritime industry. The microeconomic methodologies by definition entail an in-depth analysis; and, even with the macroeconomic methodologies, some level of industry analysis is still necessary. This is especially true with the SRI macroeconomic methodology. This methodology aggregates effects in certain industries and assumes they approximate the corresponding national effects. Because this macroeconomic analysis rests heavily on microeconomic analysis, application of the methodology to the Coast Guard regulations must begin with a thorough industry study.

In the Chase and Snell macroeconomic methodologies, the industry study is not as crucial. With the Chase model, the estimates of price increases are based on studies of supply and demand conditions in the regulated industries. The Snell model assumes two extremes concerning price increases, thereby diminishing the need for an industry study. Such a study is still valuable, though, because it can point out which pricing assumption is most reasonable.

This section of the survey provides a broad overview of the maritime industry. Its purpose is to illustrate some of the major problems which must be solved in order to perform a study of the shipping industry using the surveyed methodologies. It is not meant to be a complete catalogue of elements of shipping industry structure or performance or a complete description of existing supply and demand conditions. Once the depth of analysis has been chosen, these subjects will be reexamined in the procedures development subtask.

Each of the three microeconomic methodologies reviewed begins with a definition of the regulated industry. The maritime industry is a complex industry that makes determining the impacted segments of the industry a very complicated task. To illustrate, a Coast Guard regulation for vessels carrying hazardous material in U.S. ports or on U.S. waters would affect foreign-flag shipping; ships registered under foreign flags of convenience; privately-owned U.S. shipping; and U.S. Government-owned civilian operated shipping.

For each of these types of shipping, a primary concern is who in the U.S. bears the final burden of the costs of complying with Coast Guard regulations. To determine this burden, assumptions must be made concerning the reactions of the foreign flag fleet and the flags of convenience fleets to the regulations. The relevant question is what portion of the costs imposed on the foreign flag and flags of convenience fleets is borne by U.S. consumers or owners? This question is not addressed in the surveyed methodologies.

However, analysis of market conditions in the international ocean shipping industry, especially with regard to pricing practices, will enable the analyst to estimate the amount of foreign costs passed on to the U.S. population.

Temporarily setting this problem aside, the rest of this discussion will concentrate on the privately-owned U.S. flag fleet. Once the firms which must comply with a regulation have been identified, the reaction of these firms to the increased costs must be determined. The surveyed methodologies suggest this can be accomplished by analyzing industry supply and demand conditions and past performance and then predicting the change in industry performance which will result from production cost increases resulting from regulations.

Unfortunately, the privately-owned U.S. flag fleet consists of many segments, each one structured differently. Therefore, in order to assess correctly the impacts of regulation costs, each industry segment must be analyzed separately.

The privately-owned U.S. fleet is divided according to whether a shipping firm is engaged in international ocean shipping or in lake, river, coastwise or intracoastal domestic shipping. These two broad divisions can, in turn, be further divided. These divisions, while useful to the analysis, are not absolute. First, the study will consider the segment of the industry engaged in foreign trade and then the segment engaged in the domestic trades. The U.S. ocean shipping industry is usually divided by mode of operation. The most important division is between the operation of liners, tramps, and tankships. Liners carry freight and/or passengers and operate between fixed ports on regular schedules advertised in advance. Tramps are contract carriers. They have no fixed schedules and are chartered for a certain period of time or number of voyages. They pick up freight where and when they can profitably compete and are concentrated on the world's main shipping routes. The operations of tankships vary according to their ownership structures. Independent tankers operate in a way similar to tramps. They are usually chartered to oil companies for specific lengths of time. Proprietary tankers, in contrast, are owned and operated by oil companies and are considered an input into the production of oil and oil products.

Given these industry segments, the next step is to describe the demand and supply conditions of these segments in ways that can be related to pricing and other elements of industry performance. Important elements of demand conditions include the size and location of markets, substitute or complementary products, and demand elasticity. Important elements of supply conditions are industry concentration, ease of entry, and costs of production.

For the international ocean shipping industry supply and demand conditions do not provide a complete analytic framework. This is especially true in the United States where the industry's operations are regulated by a number of government agencies including the Maritime Administration under authority of the Merchant Marine Act of 1970. This act contains a plethora of laws concerning cargo preference, cabotage, and operating and construction subsidies. These laws and regulations pervade almost all levels of industry operations. As a result, industry performance depends on the quantity and kinds of regulations in existence, as well as on the supply and demand conditions.

Next, a brief view of the structure of the liner, tramp and tanker industries in the United States is given. The crux of all the methodologies is to determine how much prices will increase because of the costs of particular environmental or safety regulations. This discussion of industry performance is limited to pricing practices.

In the aggregate, demand for freight shipping is a derived demand; derived from the demands for the numerous products transported. There are essentially no viable substitutes for ocean shipping as a means of transporting freight between countries separated by oceans. As a result, the demand for international freight shipping in total is quite inelastic. This means a reasonable increase or decrease in shipping rates will have little effect on the volume of goods transported by sea.

In contrast, the demands for shipping certain commodities between particular ports can be either inelastic or elastic. The demand for shipping would be relatively elastic when the demand for the commodity itself is elastic; when shipping costs are large compared to the value of the commodity; or when an alternative supply (say, from another country or port) exists.

The structure of the liner industry is defined and delimited by the fact that the great majority of liner firms engaged in foreign trade are members of international shipping cartels. These cartels (called conferences) prescribe, in detail, the rates to be charged on every shipping route and for every good transported. They also restrict liner entry, allocate ports, and sometimes set cargo quotas.

Under competitive conditions, freight rates would be driven down to the level of costs. In the liner industry, the cartels are designed to eliminate this rate competition. Thus, for liners, costs can be viewed only as a lower limit to freight rates. The upper limit to freight rates is determined by the probability that tramps and non-conference liners^{12a} will enter and take over the market.

Within these bounds, cartels set rates in order to maximize profits. The profit maximizing rates will differ for each commodity according to the sensitivity of the quantity of the commodity shipped to its shipping rate. In other words, the profit-

maximizing rate depends on the elasticity of shipping demand for the particular commodity. When this demand is relatively inelastic, the cartel would set a higher rate than when demand is relatively elastic. In summary, cartels are price discriminators which set rates according to what the traffic will bear.

The fact the liner industry is cartelized has interesting implications for the problems of determining impacts of the Coast Guard regulations. As noted above, liner rates are mainly a function of conditions of demand. The Coast Guard regulations increase shipping costs; they do not affect demand for shipping services. To the extent the cartels already charge the highest possible price per commodity, the increase in production costs will be borne by the owners of the liner firms in the form of decreased profits.

Unlike the liner industry, tramps operate in a largely competitive market. The demand for tramp services arises because tramps are more efficient than liners for transporting bulk cargoes or large shipments of relatively low value commodities for which speed or regularity of transit are not important. Entry into the industry is unrestricted and, overall, international competition is significant. As a result, international tramp rates are explained in large part by the costs of operation.¹³

This is not the case, however, for the U.S. tramp fleet. The U.S. fleet does not generally compete with foreign flags for international trade. Instead, the largest source of U.S. tramp cargo is the cargo preference program. By law, government-impelled or government sponsored cargoes are reserved for U.S. flag vessels if their rates are competitive with world rates. Nevertheless, it has been estimated that rates for government cargo on U.S. flag tramps are approximately twice those of comparable cargo on foreign flag tramps.¹⁴

The structure of the tramp industry suggests an increase in production costs due to compliance with Coast Guard regulations would lead to an increase in freight rates. This would be especially true for the government-sponsored cargoes. Because these cargoes are required by law to be shipped on U.S. flag vessels, it seems reasonable to expect U.S. tramp shipping firms will be able to pass along cost increases by raising freight rates.

The tankship industry, as noted previously, is divided into two parts, proprietary and independent. Proprietary tankships are integral parts of the operation of oil companies. In the United States, they are largely a result of cabotage laws which restrict shipping between U.S. ports and U.S. flag vessels. Because proprietary tankers are factors of production to the oil companies, the relevant question with regard to the Coast Guard regulation costs is not how much tanker prices will rise as a result of the regulations, but rather how much oil prices will rise because of an increase in the price of one of its factors of production (tankers). In order to answer this question, it is necessary to analyze the oil industry to determine its reaction to an increase in the price of one of its inputs.

Independent U.S. tankships transport oil under charter to oil companies; transport other liquid cargoes under charter; and carry preference cargo, including grain, for the U.S. Government. Tanker charter rates for nongovernment-impelled cargo are determined largely by the competitive forces of supply and demand which can fluctuate widely over time. Production cost increases in the charter market are likely to be passed on in the form of rate increases at least in the long run (when contract periods have ended and rates can be reset). Rates for government-impelled cargoes are not set by a competitive, international market because these cargoes are reserved for U.S. tankers by the cargo preference laws. Thus, the demand by the government for U.S. tanker services is very inelastic, i.e., the quantity of tanker services demanded is largely unresponsive to tanker rates. Because of this inelastic demand, it is expected tanker firms would be willing and able to increase their cargo rates to cover the increased costs caused by regulations.

Besides determining the price effects, the surveyed methodologies also include steps to determine the output and profit effects of regulation costs. The reasons for this are twofold. Price, output, and profit effects in the regulated industry can be translated, through the use of one of the macroeconomic methodologies, into effects at the national level. But, perhaps more importantly, the price, output, and profit effects in the regulated industry in turn determine the effects or impacts of the regulation on other industries. A contraction of the ocean shipping industry brought about by regulation costs will have indirect effects on a great many U.S. (and foreign) industries. Identifying the U.S. industries which will be significantly affected is a difficult task.

The industries likely to be affected indirectly by price rises, service cutbacks, or firm closings in the ocean shipping industry can be classed according to whether they are customer, supplier, or competing industries. The customers of the ocean shipping industry are, of course, the firms or individuals who ship their products internationally over the world's oceans. The customers affected by Coast Guard actions are those who suffer

freight rate increases and/or service cutbacks. Only U.S. companies affected by the regulation are of concern for this study, but even with this limitation, across-the-board increases in shipping rates or decreases in shipping services affect a large number of U.S. industries. The problem, then, is to limit the number of industries studied to those which are important. The surveyed methodologies give little guidance regarding how to choose the customer industries important enough to warrant study. It should be noted that, if rate and service changes are implemented only for selected commodities and not across-the-board, the identification of the important impacted industries is a much easier task.

The next class of industries likely to be affected indirectly by Coast Guard actions are supplier industries. Again, the problem is identification of those supplier industries seriously affected by a contraction of the ocean shipping industry. Many industries and groups supply inputs to the shipping industry but, perhaps, the ones most likely to be affected significantly are the labor suppliers; the shipbuilding industry; and the industries which supply the equipment or labor required by Coast Guard regulations.

A contraction of the U.S. shipping industry would result in some unemployment of its labor force. When shipping firms cut back service or go out of business, some seamen, stevedores, longshoremen, and others directly or indirectly employed by the industry will be laid off. There are four possible results of this unemployment.

- (1) The laid-off workers will never find other employment.
- (2) They will find equally satisfactory employment immediately without incurring job search or moving costs.
- (3) They will find new employment but at lower wages or with less desirable working conditions.
- (4) They will find new employment after a period of adjustment including, for example, learning new skills or moving to a new area.¹⁵

In order to determine which of these possibilities would result, the impact study of Coast Guard regulations would require analysis of the level of unemployment in the economy as a whole and in port communities and of the skill level or labor mobility of the displaced workers. The analysis of other supplier industries, e.g., fuel suppliers, would be similar. Curtailment of the ocean shipping industry would force some adjustment of them; and, if it is during a period of general unemployment or if their resources are very specific to the shipping industry, the period of adjustment may be lengthy.¹⁶

The shipbuilding industry is connected to the shipping industry both as a supplier of shipping capital and through the workings of the subsidy programs of the Merchant Marine Act. The shipbuilding industry is characterized by large investments in highly specific, durable capital. This makes it extremely vulnerable to the decrease in the demand for new ships which might result from a contraction in the shipping industry.

This analysis is complicated by the fact that the shipbuilding industry is the industry which supplies the shipping industry with the ship design changes which might be required by the Coast Guard regulations. In the absence of subsidies, the increased costs of the new ships are likely to result in a decrease in new ship orders. However, under certain circumstances, construction differential subsidies may prevent this from happening.

The construction differential subsidy is a subsidy designed to offset financial differences between construction in American shipyards and in foreign shipyards. It is of direct benefit to U.S. shipyards, although it is given to liner firms which meet certain requirements. If the increase in the cost of new ships caused by compliance with Coast Guard regulations is paid for by a construction differential subsidy, then the regulations may not lead to a decrease in the demand for new ships.

Finally, benefits may be incurred in the industries which supply the new equipment or labor to existing ships required by the regulations. Increased employment or profits in these industries must be included as impacts of the Coast Guard regulations.

The last category of related industries are the competing industries. As noted previously, there are no viable substitutes for ocean shipping taken as a whole. However, there is substantial competition among flags and over trade routes. The effect of the Coast Guard regulations may be to decrease the attractiveness to the world's merchants of shipping their products into and out of U.S. ports. The changes in the value of U.S. exports and imports which result directly affect the U.S. balance of trade situation.

Some important questions that must be addressed in order to assess correctly the impacts of regulations imposed on shipping engaged in foreign trade have been discussed. Similar questions arise in an analysis of shipping engaged in the domestic trades in the United States. The major differences between U.S. ocean shipping and U.S. domestic shipping arise from the ways they are regulated and the competition they face.

Analysis of the domestic shipping industry must begin with a definition of that industry. Domestic water carriers can be classified geographically according to whether they engage in Great Lakes, river, coastwise, or intracoastal shipping. They can also be classified according to the regulations they face.

The economic activities of certain domestic water carriers are regulated by the Interstate Commerce Commission (ICC). The regulated water carriers include common carriers and contract carriers. Common carriers transport passengers or freight and provide regular, for-hire service over specified routes. The ICC requires common carriers to hold certificates of public convenience and necessity, to publish their rates and file them with the ICC, and to submit financial reports to the ICC. The ICC can determine common carrier rates and disallow changes in their rates.

Contract carriers transport passengers or freight under contract or charter to other companies. They are licensed by the ICC and must publish and file minimum rates with the ICC. Actual rates, however, need not be published.

The unregulated carriers include private operators transporting their own property and common or contract carriers transporting commodities exempted from regulation by the Interstate Commerce Act. These unregulated carriers do not need ICC permits to operate and are not required to submit financial statements to the ICC or to publish their rates.¹⁷

Both the regulated and unregulated domestic water carriers will bear the initial impact of the costs of Coast Guard regulations. The extent to which the regulated carriers can pass these costs onto shippers in the form of freight rate increases depends on the reaction of the ICC to increased rates. More importantly, the ability of the carriers to increase rates depends on the extent of intermodal competition.

Unlike the ocean shipping industry, domestic water carriers face existing and potential intermodal competition from railroads, trucks, and pipelines, as well as intramodal competition from other water carrier firms. The cargoes shipped by domestic water carriers are dominated by relatively few bulk commodities, both liquid and dry.¹⁸ Over the years, investments in integrated transportation distribution systems have been made to transport these commodities from their points of origin to their final destinations. These distribution systems may involve one transportation mode, e.g., all water or a combination of modes (truck and water). Existing systems differ for each major commodity group and are designed to take maximum advantage of cost differences between transportation systems.

An increase in water-borne freight rates will alter the relative attractiveness of distribution systems. As a result, shippers may choose other modes of transportation. For example, if barge rates increase, grain formerly transported by barge to New Orleans for export may switch to all-rail transport to east coast ports.

The ability of shippers to switch transportation modes may be constrained by limited access, at least in the short run, to alternative modes. For example, some shippers may have to ship by water because railroads do not come to their markets. Similarly, previous investment in transportation-related facilities may make modal switches very expensive. For example, a utility receiving its coal via water may have no facility for unloading rail cars.¹⁹

If impact analysis of the domestic shipping industry is performed by commodity groups, these differences in intermodal competition can be accounted for. In addition, commodity segmentation underscores the fact that the demand for domestic water

shipping is a derived demand, derived from the demands for the different commodities it transports. Because the demand for each commodity is different, the derived demand for water shipment of that commodity will be different. These differences in demand conditions combined with supply conditions determine the ways in which water carriers respond to the Coast Guard regulations.

The purpose of this section was to provide a broad overview of some major factors which must be addressed in order to perform a study of the impacts of Coast Guard regulations on the maritime industry. The costs of the regulations will have diverse impacts due to the importance of the maritime industry as a means of transporting a variety of goods, out of, and throughout the United States.

These impacts, however, will not be confined to the private sector alone. The public sector will bear some costs, at least initially. The major government agencies which might be affected include those operating vessels which must comply with the regulations; and the U.S. Coast Guard which develops, administers, and enforces the regulations.

The final impact of the regulation costs on government agencies depends on how the affected agencies will finance their share of the costs. The choice is between tax increases, expenditure cuts, or some combination of the two. If taxes are increased, then the taxpayers bear the burden of the regulation costs. If expenditures on other programs are decreased, then the beneficiaries of these programs bear the regulation costs. A study of the impacts of regulation costs must contain, therefore, assumptions regarding the financing of government costs.

2.4 CONCLUDING REMARKS

In part 2, microeconomic and macroeconomic methodologies for determining cost impacts were reviewed. In addition, an overview of the maritime industry was presented. At this point, it is useful to discuss how these methodologies might be applied to the costs of Coast Guard regulations.

The discussion of the methodologies illustrates that the relevant question with regard to Coast Guard regulations is not so much which methodology fits the Coast Guard's circumstances; rather, it is to decide the breadth and depth of the impact analysis required to meet Coast Guard needs. When the impacts on the maritime industry and its related industries must be assessed, microeconomic analysis will suffice. When the Coast Guard is interested in determining the wider impacts of their regulations, macroeconomic analysis can be used. The problem is deciding when to choose microeconomic analysis and when to choose macroeconomic analysis. The solution to this problem hinges on the

magnitude of the costs of the regulations. When costs are small, the macroeconomic impacts will be correspondingly small and, in fact, may be undiscernable. Under these circumstances, microeconomic analysis will deliver the most useful information.

If microeconomic analysis is chosen, the next decision concerns the elements of industry performance to study. The microeconomic methodologies are based on the economic theory which states that given market conditions and past industry performance, expected industry reaction to cost increases can be predicted. There are many elements which might be included in an industry study and, depending on the depth of analysis, the study can be limited to, say, pricing practices or can be expanded to include productivity or innovation. Microeconomic analysis, as evidenced in the three studies reviewed, is very flexible and can be tailored to fit any industry. The maritime industry is no exception. The overview of the industry suggests that the best way to study maritime industry structure and performance is by segmenting the industry. First, the industry can be divided according to that part engaged in foreign trade and that part engaged in the domestic trades. The segment engaged in foreign trade can be further divided into liners, tramps and tankships. The segment engaged in domestic trades can be divided by commodities transported. Given these divisions, the industry segments can be studied by using a combination of the three methodologies reviewed as a basic framework and by applying accepted theories of industrial organization and microeconomics to elements of the maritime industry.

This approach can give the Coast Guard much useful information. However, one shortcoming of an industry study is that it analyzes the potential impacts of regulation costs given the industry at a particular time and under specific conditions. The results of the industry study are not directly transferrable to the industry under other conditions. In other words, for regulations proposed 10 years hence, another industry study may be necessary given updated information.

When macroeconomic analysis is chosen, the important point to remember is that the validity of the results depends on the assumptions made. For example, an economic forecasting model like INFORUM is based on major assumptions regarding the way the economy works. The ability of this model to measure correctly the effects of regulation costs is necessarily limited by the fact it is only a model of the economy.

Finally, although applications of micro- or macroeconomic analysis to Coast Guard regulations are time specific, such applications are still valuable for future reference. They can point out, for example:

- (1) Significant elements of industry structure and performance.
- (2) Data sources and procedures for updating.

- (3) Guidelines or the framework for future applications.
- (4) Theoretical underpinnings.
- (5) Threshold levels of impacts.

PART 2. ENDNOTES

¹The Economic Impact of Pollution Control: A Summary of Recent Studies. Prepared for Council on Environmental Quality, Department of Commerce and Environmental Protection Agency, March 1972. The industries studied were automobile, baking, cement, electric power operators, fruit and vegetable canning and freezing, iron foundries, leather tanning, nonferrous metals smelting and refining, petroleum refining, pulp and paper mills, and steelmaking.

²For example, empirical evidence suggests that entry barriers in a highly concentrated industry affect average profit rates in that industry through higher prices. See Yale Brozen, "The Persistence of 'High Rates of Return' in High Stable Concentration Industries," Journal of Law and Economics, XIV (October 1971), pp. 501-12; or R. A. Miller, "Market Structure and Industrial Performance: Relations of Profit Rates to Concentration, Advertising Intensity and Diversity," Journal of Industrial Economics, XVII (April 1969), pp. 105-18.

³Foster D. Snell, Inc., Study of Potential Economic Impacts of the Proposed Toxic Substances Control Act as Illustrated by Senate Bill S.776 (February 20, 1975). Prepared for Manufacturing Chemists Association. June 1975.

⁴See, for example, W. S. Comanor, "Market Structure, Product Differentiation, and Industrial Research," Quarterly Journal of Economics, LXXXI (November 1967), pp. 639-57; and Edwin Mansfield, "Size of Firm, Market Structure and Innovation," Journal of Political Economy, LXXI (December 1963), pp. 556-76.

⁵K. Moll, et al, Hazardous Wastes: A Risk-Benefit Framework Applied to Cadmium and Asbestos (Menlo Park, CA: Stanford Research Institute, 1975).

⁶Ibid., p. V-13.

⁷Ibid., p. V-8.

⁸Chase Econometric Associates, Inc., The General Economy (1972), prepared for the Environmental Protection Agency, PB 207-204.

⁹Chase Econometric Associates, Inc., The Macroeconomic Impacts of Federal Pollution Control Programs (1975), prepared for the Council on Environmental Quality, PB 240-979.

¹⁰See Clopper Almon, Jr., et al. 1985: Interindustry Forecasts of the American Economy (Lexington, MA: Lexington Books, 1974).

¹¹The technical coefficients of the input/output matrix are defined as the amount of a given product used in the production of one unit of another product.

¹²Estimated costs differ between the two scenarios. This is because, in addition to the direct costs of increased testing, with maintenance of innovation, the costs of research and development are assumed to increase due to a more complex commercialization cycle. Under displacement of innovation, this effect on research and development is not included.

¹³The Soviet Merchant Fleet represents a growing source of nonconference liner competition. See Office of Policy and Plans, Expansion of the Soviet Merchant Marine Into The U.S. Maritime Trades, (Washington, D.C.: Maritime Administration, August 1977).

¹⁴See Esra Bennathan and A. A. Walters, The Economics of Ocean Freight Rates (New York: Frederick S. Praeger, Inc., 1969).

¹⁵John G. Kilgour, The U.S. Merchant Marine: National Maritime Policy and Industrial Relations (New York: Praeger Publishers, Inc., 1975), p. 93.

¹⁶Allen R. Ferguson, The Economic Value of the U.S. Merchant Marine (Evanston, Illinois: Northwestern University, 1961), p. 244.

¹⁷*Ibid.*, pp. 245-46.

¹⁸The classifications of water carriers are found in Office of Policy Plans and Development, The Barge Mixing Rule Problem: A Study of the Economic Regulation of Domestic Dry Bulk Commodity Transportation, Volume I (Washington, D.C.: U.S. Department of Transportation, 1973), Section II.C.

¹⁹The major commodity groups are coal, grain, fertilizer, petroleum, iron and steel, sand and gravel, industrial chemicals, and salt. See David L. Anderson, et al. Model Traffic Impacts of Waterway User Charges, Volume II (Washington, D.C.: Department of Transportation, 1977).

²⁰*Ibid.*, Volume I, p. 3.

3. FINDINGS

The survey of methodologies for both the efficiency and equity portions of the economic analysis indicated that few methodologies or models are developed with other than specific guidelines to solve well defined problems. This fact poses a particular problem for the efficiency side of the approach. However, the underlying concepts found in the surveyed studies can be viewed as providing the background for the procedure development efforts. The simple repackaging of available models/methodologies to meet Coast Guard needs is complicated by the requirement to measure the incremental costs due to changes in regulations. The methodologies/models reviewed have been constructed to estimate levels of costs, and can only be applied to estimating incremental costs in specific cases under the strict set of assumptions mentioned in section 1.3. Therefore, in the procedures development subtask, generalized procedures to fit the Coast Guard needs were built using existing methodologies as information sources. A simple repackaging of existing models would leave severe gaps.

Potential procedures for estimating the impacts of regulations have been identified in part 2. Microeconomic analysis is applicable to assessing the impacts on the maritime and related industries. However, this analysis does not provide an indication of the effects on the entire economy. The utilization of macroeconomic analysis and models can provide the framework within which these wider impacts can be determined.

Microeconomic analysis is a necessary step even if the estimation of macroeconomic impacts is desired. When costs are small, the macroeconomic impacts will be correspondingly small and, in fact, may be undiscernable. Under these circumstances, microeconomic analysis will provide the most relevant information. If cost are large, macroeconomic indicators must also be assessed. Microeconomic analysis is very flexible and can be tailored to fit any industry. The maritime industry can best be studied by segmenting the industry: first, by foreign and domestic activities; then, by types of operation and commodities transported.

The shortcoming of an industry study is that it is time specific and depends upon the general economic, political and social setting that exists. However, such an industry study is valuable for future reference since it can indicate:

- (1) Significant elements of industry structure and performance.
- (2) Data sources and procedures for updating.
- (3) Guidelines or the framework for future applications.
- (4) Theoretical underpinnings.
- (5) Threshold levels of impacts.

ATTACHMENT A
Workload Components

Person Hours/Component

INSPECTION (V)

Foreign Vessels (F)

VF ₁	- Letter of Compliance	9
VF ₂	- Verification	6
VF ₃	- Reinspection	6
VF ₄	- Persons in Addition	4

Certification (C)

CVLP	- Large Passenger	48
CVSP	- Small Passenger	4
CVC	- Cargo Vessel	46
CVCS	- Cargo Vessel - Small	8
CVT	- Tank Vessel	55
CVTS	- Tank Vessel - Small	8
CVBT	- Barge-Tank	4
CVBF	- Barge-Freight	4

Drydock (D)

DVLP	- Large Passenger	19
DVSP	- Small Passenger	3
DVC	- Cargo Vessel	25
DVCS	- Cargo Vessel - Small	9
DVT	- Tank Vessel	31
DVTS	- Tank Vessel - Small	4
DVBT	- Barge-Tank	7
DVBF	- Barge-Freight	7

Reinspection (R)

RVLP	- Large Passenger	12
RVSP	- Small Passenger	3
RVC	- Cargo Vessel	28
RVT	- Tank Vessel	30
RVBT	- Barge-Tank	3
RVBF	- Barge-Freight	3

Attachment A (continued)

Person Hours/Component

Shorts (S)

SR	- Requirements, Repairs, and Deficiencies	2
----	--	---

INVESTIGATIONS (I)

Casualty (C)

CIB	- Marine Board	220
CIM	- One-Man Formal	60
CIN	- Narrative	25
CIT ₁	- Transmittal - Investigation	10
CIT ₂	- Transmittal - No Investigation	3
CIF	- Closed to File or Forwarded	3

Personnel (P)

PIH ₁	- Hearing - Witnesses	20
PIH ₂	- Hearing - No Witnesses	10
PIW	- Warning	4
PID	- Dismissal - Closed No Action	4
PIA	- U.S. Attorney Case	20
PIF	- Case Forwarded	3
PIS	- Surrender	4
PIV	- Voluntary Deposit	3

Motorboat (MB)

CMB	- Narrative	20
CMB	- CG04885	8
CMB	- Forward - No Investigation	3

Pollution (P)

CP	- R.S. 4450 Action	8
----	--------------------	---

FACTORY INSPECTIONS (F)

F₁
↓
F_n

Attachment A (continued)

Person Hours/ComponentNEW CONSTRUCTION (N)

NC	- Construction Man-Days	X 8
NA	- Conversion - Alteration Man-Days	X 8

LICENSING (L)Original (O)

LOM	- Mate/Master	9
LOE	- Engineer	8
LOP	- Pilot	7
LOO	- Ocean Operator	2
LOT	- Towing	3
LOI	- Inland Operator	2
LOB	- Motorboat Operator	2
LOS	- Special	3

Upgrade/Extension (U)

LUM	- Mate/Master	5
LUE	- Engineer	5
LUP	- Pilot	5
LUO	- Ocean Operator	2
LUT	- Towing	2
LUI	- Inland Operator	2
LUB	- Motorboat Operator	2
LUS	- Special	2

Renewal (R)

LRM	- Mate/Master	1
LRE	- Engineer	1
LRP	- Pilot	1
LRO	- Ocean Operator	1
LRT	- Towing	1
LRI	- Inland Operator	1
LRB	- Motorboat Operator	1
LRS	- Special	1

Attachment A (continued)

Person Hours/Component

Merchant Mariner Documents (M)

MO	-	Original - Entry	0.75
MA	-	Able Seaman	2
ML	-	Lifeboat Man	1.5
MQ	-	Qualified Member Engine Department	1.5
MT	-	Tankerman	1.5

Failures (F)

LFM	-	Mate/Master	5
LFE	-	Engineer	5
LFP	-	Pilot	4
LFO	-	Ocean Operator	1.5
LFT	-	Towing	2
LFI	-	Inland Operator	1.5
LFB	-	Motorboat Operator	1.5
LFS	-	Special	2

Source: Marine Inspection Office and Billet Distribution Study, 1974.

ATTACHMENT B

Variances

<u>Function</u>	<u>Man-Hours</u>	<u>Number Billets</u>
WLE and WEP	41,274	24.56
Training (Special School)	10,464	6.22
Documentation and Admeasurement	6,690	3.98
Unique Situations (VTS, Flood Relief, Speed Control, etc.)	4,566	2.71
P.E. Boards	2,772	1.65
Procurement (Cadet, OCS and Direct Commission)	2,382	1.41
Others (CG Investigations, Court Martials, etc.)	1,754	1.04
Public Relations	1,032	0.61
Recreational Boating	656	0.39
Seasonal Variation - Great Lakes Lay-Up	198 Vessels	
Total	71,620	42.60

Source: Marine Inspection Office and Billet Distribution Study, 1974.

ATTACHMENT C
Total Workloads Performed Under MEP/PSS At MSOs

<u>COTP/MSO</u>	<u>Man-Hours/MEP/PSS</u>	<u>Billets</u>
<u>1st District</u> Providence	1,764	1.05
<u>2nd District</u> Nashville	3,096	1.84
Dubuque	1,552	0.92
Paducah	840	0.50
St. Louis	420	0.25
Memphis	960	0.57
Pittsburgh	1,500	0.89
Huntington	3,588	2.14
Cincinnati	1,624	0.97
Louisville	2,228	1.33
	<u>15,808</u>	<u>9.41</u>
<u>3rd District</u> Albany	1,842	1.10
<u>5th District</u> Norfolk	2,828	1.68
Wilmington	1,176	0.70
	<u>4,004</u>	<u>2.38</u>
<u>7th District</u> Savannah	3,024	1.80
Jacksonville	1,344	0.80
Tampa	1,008	0.60
	<u>5,376</u>	<u>3.20</u>
<u>8th District</u> Corpus Christi	1,344	0.80
<u>9th District</u> Cleveland	420	.025
Toledo	2,688	1.60
Chicago	1,512	0.90
	<u>4,620</u>	<u>2.75</u>
<u>12th District</u> San Francisco	1,672	1.00
<u>13th District</u> Portland	1,596	0.95
<u>14th District</u> Guam	2,100	1.25

Attachment C (continued)

<u>COTP/MSO</u>	<u>Man-Hours/MEP/PSS</u>	<u>Billets</u>
<u>17th District</u> <u>Anchorage</u>	2,160	1.29
Other Offices Not COTP/MSO	3,074	1.83
Total	45,360	27.0

Source: Marine Inspection Office and Billet Distribution Study, 1974.

ATTACHMENT D
DEFINITIONS OF COST TERMS*

1. Analogy Cost Estimating - employs a specialized method of judgment to measure the costs of items, systems or programs by making direct comparisons with historical cost data for similar items, systems or programs.
2. Cost Estimating Relationship (CER) - an equation relating the costs of an item, system or program to one or more physical or performance characteristics. CERs are developed by deriving functional relationships using statistical techniques, e.g., regression analysis on historical data. Note: Developing cost estimating relationships involves employing parametric cost estimating techniques defined below.
3. Cost Factors - a cost factor is a single multiplier such as average personnel cost per person hour or standard prices listed by the Coast Guard or contractors.
4. Delphi Cost Estimating - is a method to estimate costs of an item, system or program based on expert opinion. It is usually accomplished through the use of questionnaires and interviews.
5. Engineering Cost Estimating (also known as Factor Cost Estimating) - consists of consolidating known cost estimates from various work segments to get a total system or project estimate. For example, an engineering cost estimate of new vessel construction might consist of aggregating the labor, material and overhead costs of three vessel work segments: steel, outfit and machinery.
6. Life Cycle Cost - the total discounted cost of the item, system or program over its entire economic life. For example, vessel life cycle cost is made up of the research and development, investment and operating costs of the vessel over its economic life, say 25 years, discounted back to the present.
7. Parametric Cost Estimating - involves developing a functional relationship between costs of items, systems or programs and certain measurable parameters or explanatory variables. The functional relationship developed is a cost estimating relationship (CER). An example of parametric cost estimating is estimating the cost of vessel hull as a function of the parameter, steel weight.

*Sources for these include A. D. Stament, et al., Economic Analysis Handbook Theory and Application (McLean, Virginia: General Research Corporation, 1973) and R. S. Brown, et al., Economic Analysis Handbook (Alexandria, Virginia: Naval Facilities Engineering Command, 1975).

SECTION III

DESCRIPTION OF THE DEVELOPMENT OF PROCEDURES FOR COSTS AND COST IMPACTS OF MARINE SAFETY REGULATIONS

The purpose of this Section is to provide background information to document the scope, work effort and decisions underlying the development of the Procedures Manual segments.

This Section is divided into 4 parts as follows:

- A. Main Lines of Investigation and Scope of Effort
- B. Critical Issues
- C. Description of the Manual Segments
- D. Capabilities and Limitations of the Manual

The Procedures Manual itself is contained in Appendix A.

A. Main Lines of Investigation and Scope of Effort

The main lines of investigation and scope of effort addressed cost methodologies that would assess the costs and cost impacts of specific Coast Guard actions which affect:

- 1. Vessel design
- 2. Vessel equipment
- 3. Vessel staffing and licensing
- 4. Vessel inspection intervals and requirements
- 5. Operational controls

The scope of the effort had as its objective the development of procedures that would be generally applicable to assessing the costs and impacts of proposed regulatory actions. These regulatory actions, subject to analysis, would have significant quantifiable impacts on the marine transportation industry.

Several limitations were placed on the investigation due to limits on personnel time, and resource availability. These limitations affected the scope of problems/issues that the final procedures manual is specifically designed to handle. The focus of the procedures in the Cost Manual is on U. S. industry, Government and consumers. However, the procedures, as developed, are applicable to determining foreign costs. Additionally, the orientation of the manual is on analyzing regulatory actions. Other types of cost analysis problems encountered by the marine industry were not specifically investigated.

B. Critical Issues

The purpose of cost-benefit analysis is to determine the economic feasibility of a defined project, project component or system and to determine the most economically feasible alternative among regulations, projects or systems that have a similar function. The life cycle cost methodology is one approach for comparing alternatives. It provides a framework for aggregating cost components over the life of the regulation, project, system or project component. A number of techniques for estimating cost components were examined in the Methodology Survey.

The choice of an appropriate costing technique is dependent upon the project to be costed, the degree of accuracy required and the availability of data. Four costing techniques were examined in detail to determine which ones were best suited for assessing the costs of Coast Guard regulatory actions under the CVS Program. Each of these is discussed below.

In addition, a number of other issues that are key factors in any cost estimation were examined. These included the use of discounting, an appropriate time horizon, escalation factors, capital costs, identification of applicable levels of detail for cost elements and the level at which macroeconomic impacts are analyzed.

Costing Techniques

The costing techniques discussed below are listed in the preferred sequence of choice for the analyses of regulations. The first method discussed will, in most cases, result in more detailed and defensible estimates of future benefits. However, this method is dependent upon the availability of data.

1. Engineering

This method is often applied to the estimation of incremental component costs. It aggregates individual cost component estimates into a total project estimate. This method can be used whenever detailed costs estimates are required and data are available. Its benefits are its functional simplicity and general applicability. The fundamental problem with this method is that original cost factor estimates are required for each regulation analyzed. For example, the estimated cost of new equipment for a vessel might require separate estimates of the cost of each component of the equipment. The cost of each component is then aggregated into a total system estimate.

2. Parametric

The cost of an alternative, using this method, is based upon performance and physical characteristics and their relationship to aggregated component costs. A functional relationship must be established between the total cost of an alternative and the parameters of the alternative. The method requires that the data used to determine the parameters are representative of current conditions. As an example, a barge operator contemplating the purchase of a new barge might consider the following parameters: length; width; hull design; equipment, etc. If the price of a barge with a particular combination of these parameters is known, then prices for other combinations of these parameters may be estimated relative to the known barge price.

3. Analogy

Analogy costing draws an analogy between the characteristics of a system with known costs and the system under consideration. This technique is critically dependent upon the analysts' ability to accurately formulate the required analogy for the system under consideration. The analyst or "expert" may estimate the cost of constructing a new

vessel based upon the "expert's" recent experience with actual labor, materials and overhead construction costs, adjusting for known differences in the new vessel.

4. Delphi

This is an estimating technique based upon expert opinion, used primarily when historical data do not exist or are unavailable. The accuracy and reliability of this technique is highly dependent upon the group of experts performing the analysis and the manner in which the exercises are conducted. Cost estimates, using this technique are usually obtained through questionnaires or interviews.

Other Issues

1. Discounting

The Cost Manual procedures recommend the use of discounting as the means of recognizing the time value of money in cost-benefit analysis. Money is a productive resource that commands a price for its use. A dollar today is not the same as a dollar five years from today. Decisions about whether to undertake projects involve a commitment of resources in the future as well as in the present. Discounting converts dollar amounts of costs and benefits expended or received in different years into their present value.

The interest rate at which future costs and returns are discounted to present value is the discount rate. Any project analysis is sensitive to the value of the discount rate. Discounting at a positive rate gives greater weight to costs and returns the earlier they occur. High discount rates tend to favor those alternatives with costs occurring relatively late and benefits occurring relatively early. The discount rate represents the return foregone by investing in one project (or complying with a regulation) over another investment alternative.

2. Time Horizon

Another decision that must be made in assessing the costs and benefits of regulations is the choice of a time horizon. Theoretically, the time horizon for the analysis of a regulation should be the effective life of the regulation. Realistically, the time horizon must be limited.

The suggested method of limiting the time horizon is to limit it to the economic life of the alternative. Three factors that limit the duration of economic life are: mission life, the period over which the asset is needed; physical life, the period over which the asset will last physically; and technological life, the time before obsolescence would require replacement. Economic life should generally be the lesser of these three time periods.

The Procedures Manual recommends using an economic life of 25 years for vessels. Vessel equipment economic life should be assumed at the lesser of the three alternatives discussed above. The criteria for choosing a time horizon for regulations concerning vessel inspections and personnel training are less concrete. However, it is recommended that the maximum time horizon for any analysis be limited to 25 years since annual (discounted) costs are increasingly insignificant beyond this point.

3. Inflation

Inflation can be a complicating factor in any economic analysis of alternatives since the trend in prices, rate of inflation, can only be estimated. The recommended method for comparing regulatory alternatives is to estimate all costs and benefits in constant dollars. The only exception would be cases in which some cost element(s) is expected to experience abnormal long term escalation.

4. Capital Costs

All projects that require investment require the firm, individual or Government to generate funds to finance the investment. These funds may be generated internally or borrowed at the prevailing interest rate. The interest rate represents the cost of borrowing funds in the money market. The interest expense must be included in the total cost of any investment.

The problem for the regulatory staff is to decide upon an appropriate interest rate and payback period. The payback period is dependent upon the type and size of the capital investment. The following table illustrates the significance of interest expense in estimating total investment costs. To obtain total investment costs multiply the cost of capital times the appropriate factor. The factor takes into account the annual interest rate and the payback period.

<u>Annual Interest Rate</u>	<u>Payback Period</u>	<u>Factor</u>
10%	5 years	1.32
10%	10 years	1.63
12%	10 years	1.77

To illustrate, if \$10,000 is borrowed at a 10% annual interest rate to be paid back in ten equal annual installments multiply \$10,000 times 1.63. The total investment cost is then \$16,300.

5. Level of Detail

Costs

The level of detail that is desirable or achievable in estimating the costs of regulatory actions will be limited by the time available to perform the analysis, the level of detail at which a risk assessment can be conducted, the degree of accuracy required and the availability of data. Examples of data constraints are: the level of detail of vessel population available in fleet forecasts; the availability of cost data for the system under consideration; and, the difficulty in placing dollar value on some costs such as lost cargo capacity. In all cases the analyst must exercise judgment in determining the appropriate level of detail.

Cost Impacts

Cost impacts can be traced either by using an input-output model when the cost impacts are of sufficient magnitude or, when the impacts are of lesser magnitude, by tracing the impacts through sectors of the economy.

Input-output models use complex computer systems that require a level of expertise. Additionally, use of these models is costly and the accuracy of the results are dependent upon the data base used in the model.

C. Description of the Manual Segments

During development of this manual it became apparent it would be beneficial to the Coast Guard to provide a "how to" format which would provide step-by-step cost procedures pertinent to several aspects of the Commercial Vessel Safety Program. The principal advantages of developing such a manual include: (a) having an open-ended document which can be supplemented with additional material, e.g., benefit procedures; and (b) providing a document which can be updated annually and used regularly rather than a one-time report.

The manual is designed to aid in the regulatory evaluation process. To meet this goal the manual contains procedures for calculating costs and benefits, formats for categorizing and tallying the costs and benefits of alternative regulations, and procedures for tracing major impacts of costs throughout the economy.

The procedures manual is divided into ten sections as follows:

I. INTRODUCTION

A brief description of the objectives of the manual.

II. METHODOLOGY OVERVIEW

A discussion of how marine safety cost-benefit analysis relates to overall risk management in reducing marine accidents, to include basic steps in conducting cost-benefit analyses.

III. ASSUMPTIONS AND DEFINITIONS

This section is used to define the scope and ground rules of the cost-benefit analyses to be conducted. It itemizes commonly used techniques and assumptions employed in cost-benefit analysis.

IV. COST CATEGORIES AND ELEMENTS

Provides a listing of cost categories and cost elements used to collect costs of regulatory actions.

V. FORMATS FOR COST MEASUREMENT

Formats contained in this section provide the structure for calculation of all total costs to be incurred by industry and government to implement a regulation.

VI. COST PROCEDURES AND FACTOR DEVELOPMENT

This section explains how to develop cost factors, techniques to be employed in making cost estimates and guidance on what to look for in developing regulatory costs for vessel design, equipment, staffing, licensing, inspection and regulatory operating changes.

VII. COST FACTORS

This section contains a collection of selected cost factors which may be employed to fill in formats contained in section V (in selected cases, particularly vessel operating costs).

VIII. FLEET FORECAST

This section contains projections of anticipated additions and deletions of commercial vessels to the U.S. and World fleet over the next 30 years. This is useful to estimating costs associated with vessels of varying ages which are impacted by regulatory changes.

IX. COST IMPACT PROCEDURES

This section explains procedures to trace the impacts of regulatory generated costs and prices as they pass through the economy to ultimate consumers. It is designed to show macro- and microeconomic impacts associated

with regulatory action where measurable. Discussion focuses on use of a computerized input-output model titled INFORUM.

X. EXPECTED IMPACTS OF CVS REGULATIONS

This section contains an example which helps the analyst trace cost impacts of regulatory actions. It is particularly useful when regulatory cost impacts are not large enough to be measured on the computerized input-output model (INFORUM) used to trace cost impacts throughout the economy.

D. Capabilities and Limitations of the Manual

This section describes the capabilities and limitations of the Cost Manual segments. It is divided into two parts related to the two separate types of procedures: cost measurement procedures and cost impact procedures. The former category is designed to identify all costs to industry and government of implementing alternative regulatory safety measures. For example, how much will it cost shipbuilders to put double bottoms on eligible U.S. vessels? The other type of procedures mentioned, cost impact procedures, are designed to answer such questions as: If tanker prices go up because of a double bottom regulation, how much will that increase gasoline prices at the pump?

Because of the differences in methodologies used to develop cost measurement and cost impact procedures, each will be discussed separately. The discussion is further subdivided into capabilities and limitations. The limitations section includes a discussion of the technical problems likely to be encountered. These include unavailability of data, lack of direct access to certain data and problems encountered in using complex computer programs. Sections II and III of the manual are devoted to Methodology Overview and Assumption and Definitions. These will only be mentioned where they are germane to the discussion of the procedures development.

1. COST MEASUREMENT PROCEDURES

a. Cost Measurement Procedure Capabilities

These capabilities are broken down into four areas:

(1) Cost Categories and Elements (Section IV)

All types of costs for most cost measurement systems must be categorized so the analyst will have a uniform way of collecting and calculating costs. Such questions must be resolved as: Should all of the vessel operating costs be combined or is it better to have several cost elements under operating costs? It is assumed that the categories and cost elements currently contained in the manual will be changed as the manual is put into use.

(2) Formats for Cost Measurement (Section V)

In order to estimate the total costs of implementing a regulation, it is necessary to do so over the life cycle of the hardware or system being evaluated. When looking at the life cycle of commercial vessels, the U.S. fleet presents a confusing picture since the inventory contains vessels of widely varying ages. Twenty-five years is representative of the life cycle of an average vessel. Additionally, since discounting is employed, costs become increasingly insignificant in the later years of a 25 year time horizon. Therefore, a time horizon of 25 years was selected for the cost measurement analysis.

As different vessels enter the fleet, it becomes exceedingly difficult to keep track of the time frame when costs are incurred. It was necessary to design a series of 7 individual formats to plot annual costs to industry and the government every year in the 25-year time horizon. Format 1 provides industry cost categories. Format 2 allows for collection of industry investment and operating costs over the time horizon for new vessel construction and retrofits for one class of vessel (e.g., tankers over 125,000 DWT). Format 3 summarizes industry costs by category for one class of vessel while Format 4 summarizes costs for all vessel classes and includes provisions for discounting. Formats 5 and 6 do essentially the same thing as Formats 1-4 except they are designed to calculate

1. COST MEASUREMENT PROCEDURES

a. Cost Measurement Procedure Capabilities

These capabilities are broken down into four areas:

(1) Cost Categories and Elements (Section IV)

All types of costs for most cost measurement systems must be categorized so the analyst will have a uniform way of collecting and calculating costs. Such questions must be resolved as: Should all of the vessel operating costs be combined or is it better to have several cost elements under operating costs? It is assumed that the categories and cost elements currently contained in the manual will be changed as the manual is put into use.

(2) Formats for Cost Measurement (Section V)

In order to estimate the total costs of implementing a regulation, it is necessary to do so over the life cycle of the hardware or system being evaluated. When looking at the life cycle of commercial vessels, the U.S. fleet presents a confusing picture since the inventory contains vessels of widely varying ages. Twenty-five years is representative of the life cycle of an average vessel. Additionally, since discounting is employed, costs become increasingly insignificant in the later years of a 25 year time horizon. Therefore, a time horizon of 25 years was selected for the cost measurement analysis.

As different vessels enter the fleet, it becomes exceedingly difficult to keep track of the time frame when costs are incurred. It was necessary to design a series of 7 individual formats to plot annual costs to industry and the government every year in the 25-year time horizon. Format 1 provides industry cost categories. Format 2 allows for collection of industry investment and operating costs over the time horizon for new vessel construction and retrofits for one class of vessel (e.g., tankers over 125,000 DWT). Format 3 summarizes industry costs by category for one class of vessel while Format 4 summarizes costs for all vessel classes and includes provisions for discounting. Formats 5 and 6 do essentially the same thing as Formats 1-4 except they are designed to calculate

government costs. Format 7 allows for a comparison of government and industry costs for various regulatory alternatives.

(3) Cost Procedures (Section VI)

This section is divided into six parts discussing cost procedures for: vessel design, vessel equipment, vessel staffing, vessel licensing, vessel inspection, and vessel operating costs. Without dwelling on the specifics of each of these sections, the general thrust of each involved detailing:

- What to look for when developing costs.
- Pitfalls to avoid in developing costs.
- Who to contact to get input for costs.

In most instances, cost estimates must be furnished by other government sources which maintain cost data bases or have special estimating capabilities. One such agency is the U.S. Maritime Administration. Virtually all vessel design, staffing and operating cost data or estimates may be obtained from offices within this administration.

In other cases, such as Coast Guard training costs, the Marine Safety School which prepares estimates in Yorktown, Virginia, suggested analysts call them directly to request special estimates rather than including procedures or cost factors in this manual.

(4) Cost Factors (Section VII)

Several factors contained in this section were a by-product of procedures development. It was concluded that the manual should have a single section which presents commonly used cost factors, such as personnel costs, listed in other Coast Guard publications.

b. Cost Measurement Procedure Limitations

(1) Formats for Cost Measurement

Using these formats correctly requires paying a great deal of attention to details, (e.g., it can be difficult keeping track of vessels phasing in and out of the U.S. fleet).

(2) Fleet Forecast

One of the main problems confronted in developing formats and procedures was identifying a suitable forecast of the size and mix of vessels phasing into and out of the fleet over future years. There is a general consensus that, as vessels increase in size, the number within the fleet will decline. One of the few comprehensive fleet forecasts which shows annual incremental changes is a recently completed Temple, Barker and Sloane, Inc., study done for the Office of Commercial Development, U.S. Maritime Administration. The TBS methodology is the best available current source for a fleet forecast. The TBS report has some limitations including: a classification system for vessel types which may not readily satisfy the Coast Guard analyst's requirements; a focus upon the worldwide fleet rather than U. S. flag fleet; a tendency toward aggregated data which cannot be broken down easily into detailed levels; and a time horizon extending only to the year 2000. The Fleet Forecast section of the manual recommends methods of adapting the forecast to meet the analysts needs.

(3) Cost Factors

The main limitation in developing cost procedures, particularly those related to vessel operating costs, is an inability to investigate the sources of the numbers. In the case of Marad generated vessel operating cost data, cost averages are derived by using industry furnished actual data which are proprietary. Marad made it clear that under no circumstances would other than summary data and cost factors be furnished in order to protect the confidential data submitted by the industry.

In the development of vessel operating cost procedures another constraint is that casualty data bases necessary for risk assessments of vessels do not identify non-tankers over 15,000 deadweight tons. Therefore, a gross average had to be employed since it is pointless to develop more refined cost factors if the risk output is constrained by these data bases. Additionally, averaging had to be used to match deadweight tons of cargo vessels with vessel type (e.g., C-3, C-6, etc.).

One of the largest expenses incurred in operating tankers is the cost of fuel. Since the cost of fuel varies worldwide and consumption is dependent upon routes and number of days at sea, average scenarios of short, intermediate and long hauls were used to arrive at daily fuel operating costs. The requirement for daily operating cost factor development

arises if a candidate regulation may result in vessel delay (e.g., clearing channels for LNG dockings).

(4) Cost Procedures

Most of the limitations associated with the cost procedure development are fully documented in section VI of the manual. One area of refinement of potential interest to the Coast Guard in the future is associated with commercial vessel staffing. The Maritime Manpower Impact System is a computerized system administered by the Office of Maritime Manpower. It contains union and personnel cost information for U.S. tankers and dry cargo vessels engaged in foreign trade. The information contained in the system is updated annually.

The system has the capability of listing, for individual vessels, the personnel cost (separated into wage and benefit categories) per crewmember per day, month or year or the total vessel personnel cost per day, month or year. It can also determine the average personnel cost per crewmember and the average total vessel personnel costs by vessel type. It is these averages which will be of most use in cost-benefit analysis of CVS regulations.

The estimated cost of obtaining the computer averages from the Office of Maritime Manpower is approximately \$2000. There is no charge for listing out the personnel costs per crewmember for all the individual vessels contained in the tanker and dry cargo computer file. The 1977 list was used as input to section VII of the manual.

AD-A098 314

PRC SYSTEMS SERVICES CO MELEAN VA
COMMERCIAL VESSEL SAFETY. ECONOMIC COSTS. PRELIMINARY. (U)
DEC 79 C A CROOK, M L PATTERSON

F/G 5/4

UNCLASSIFIED

USCG-D-1-81

DOT-CG-351-A

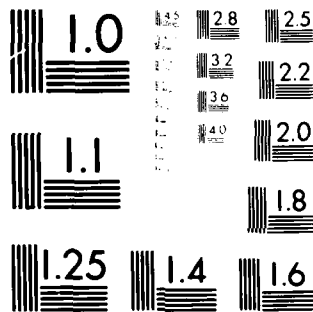
NL

2 of 2

AD-A098 314



END
DATE
FILMED
5-81
DTIC



MICROCOPY RESOLUTION TEST CHART
 NATIONAL BUREAU OF STANDARDS-1963-A

2. COST IMPACT PROCEDURES

a. Cost Impact Procedure Capabilities

(1) Background

The purpose of cost impact procedures is to be able to track cost and subsequent price increases which result from a regulatory action. If there is a vessel design change for tankers, the cost of incorporating this change will likely be passed on in increased fuel prices, etc. It is also useful to the decision maker to know if regulatory action will have any impact on Gross National Product, employment, imports-exports, etc.

Some of these impacts may be tracked and measured by use of input-output techniques which relate economic activity in industrial sectors to each other and national income accounts. Although the details of input-output relationships and calculations are somewhat complicated, Figure 3 provides a simplistic view of the relationships of industries to each other and final markets. Key features are as follows:

- Columns show what each industry buys as inputs from itself, from other industries and from labor, capital and government.
- Rows show what each industry sells to other industries and to personal consumption, investment, exports and government.

Although a full description of basic input-output relationships is contained in the Survey of Current Business, November 1969, Volume 49, No. 11, U.S. Department of Commerce, key features are as follows:

(2) INFORUM

The Interindustry Forecasting Model of the U.S. Economy (INFORUM) is an input-output model created and maintained by the University of Maryland. It provides the capability to:

Figure 3

INPUT-OUTPUT FLOW TABLE

		PRODUCERS								FINAL MARKETS			
		Agriculture	Mining	Construction	Manufacturing	Trade	Transportation	Services	Other	Persons	Investors	Foreigners	Government
PRODUCERS	Agriculture												
	Mining												
	Construction												
	Manufacturing									Personal consumption expenditures	Gross private domestic investment	Net exports of goods and services	Government purchases of goods and services
	Trade												
	Transportation												
	Services												
	Other												
VALUE ADDED	Employees	Employee compensation								GROSS NATIONAL PRODUCT			
	Owners of Business and Capital	Profit-type income and capital consumption allowances											
	Government	Indirect business taxes and current surplus of govt. enterprises, etc.											

U.S. Department of Commerce, Office of Economic Research

10-44-42

- Trace interindustry impacts in the crude petroleum and water transportation sectors if regulatory costs* approach the following amounts in any given year:
Crude Petroleum - \$700 million
Water Transportation - \$1000 million
- Identify impacts on GNP, personal consumption, wholesale prices, and employment of minimum price increases of 10 percent in the case of water transportation and 2.5 percent in the case of crude petroleum.
- Present selected final price impacts to consumers, for example, the increase in the price of gasoline at the pump from requiring tankers to have double bottoms.

The methods used to arrive at these thresholds are as follows:

- Water Transportation - Look** at the INFORUM base run. Go to the section titled "Product Shipments in Producer Prices (millions of 1976 \$). Find Sector 170, Water Transportation. Read across the rows. All entries range from \$10-12 billion. A 10 percent price increase on the bottom end of this range results in a \$1 billion threshold.
- Crude Petroleum - Sector 15 requires two adjustments to output data before thresholds can be tabulated. The first problem is that sector 15 consists of both crude petroleum and natural gas. The latter must be stripped out of the total. The second problem is to find a means to subtract imports from crude petroleum output since the principal concern is with the impact of a price increase on U.S. tankers to meet a regulatory requirement.

To arrive at the crude petroleum cost threshold, go to the INFORUM Matrix Listing of Seller-Buyer Relationships. Note first that Sector 15 consists of both crude petroleum and natural gas production. Next, note that total domestic output

* As extracted from column 10 of Format 4 in the manual.

**INFORUM computer runs are available from PRC and from the United States Coast Guard (G-DMT-1)

of both is listed at \$40,003 million. The problem is how to segregate domestic crude petroleum output from natural gas output included in this figure. First assume all sales (\$57,527.9 million) to Sector 76, Petroleum Refining, represent 100 percent crude petroleum sales. Next look at imports of both natural gas and crude petroleum which total \$30,725.7 million. The INFORUM staff estimates 94 percent of imports are crude petroleum or \$28,882.16 million. Subtract crude imports (\$28,882.16 million) from total petroleum refining sales (\$57,527.9 million) to arrive at an approximation of total domestic output of \$28,645.74 million. Two and one-half percent of \$28,645 million is approximately \$716 million. Note it would take about a \$700 million cost impact in 1 year for a tanker regulatory action to generate sufficient impact to run the INFORUM model.

b. Cost Impact Procedure Limitations

As with any generalized model attempting to forecast complex relationships, there are many limitations to the INFORUM model. The following are considered significant:

(1) Cost Thresholds

Thresholds exist for which regulatory cost impacts must be equal to or greater than in order to show up in INFORUM measurements. These have already been explained.

(2) Data Base

The INFORUM staff is not confident the base data being employed in the model for the water transportation sector is the best available and suggested the Coast Guard may have an interest in investigating alternative sources to improve the data base. The data currently being used are considered both incomplete and inaccurate.

(3) Cost of Use

Use of the INFORUM model and model consultations is expensive. The INFORUM fee schedule is as follows:

- Five thousand dollars for annual subscription (computer access at the University of Maryland).
- Three thousand dollars additional if the Coast Guard wishes to purchase the INFORUM tape, \$1,000 each year thereafter.
- Three hundred dollars/day for instruction /consulting if assistance is required from the INFORUM staff.
- Two hundred fifty dollars/computer run (approximate) to trace one price increase.

The appropriate point of contact for INFORUM at the University of Maryland is Ms. Margeret Buckler, telephone (301) 454-5384.

c. General Manual Limitation

Cost benefit analysis is a tool that provides the decision-maker with part of the information necessary for choosing among regulatory alternatives. The procedures manual methods for assessing tests and cost impacts do not address many of the non-quantifiable elements that should be considered in the decisionmaking process. These include the potentially adverse effects of regulations on a particular region or community and/or on individual firms within an industry by driving some firms out of business or causing firms to relocate.

SECTION IV

DESCRIPTION OF PROCEDURE EXAMPLES

Three exercises of the procedures manual were carried out on three different Governmental actions, producing a variety of costs and cost impacts. Two proposed U. S. Coast Guard regulatory actions and one continuing operational problem were chosen as the subjects for these exercises.

Example I: Proposed Tankerman Regulations

Example II: Double Hull Retrofit for Existing Tank Barges

Example III: Vessel Delays at the Hackensack River Portal Bridge

The overall objective of the exercises was to determine weaknesses in the methods and procedures as developed. In addition, these examples of applications of the procedures manual to actual regulatory issues provide manual users with a useful reference for future regulatory analyses. In all three exercises an attempt was made to quantify only the cost portion of the procedures. Cost impacts were described in as much detail as possible. No attempt was made to run the INFORUM model. It is unlikely that the costs associated with these regulations were significant enough to impact the model.

A brief description of each of these exercises is provided below. A complete report on each exercise including background information, technical approach, and results of each exercise is included in Appendix B of this report.

Example I - Proposed Tankerman Regulations

The subject for this example was proposed Coast Guard regulations governing the qualifications of personnel involved in the handling, transfer and transportation of dangerous cargoes in bulk aboard ships and barges. The purpose of the regulations is to redefine and establish more satisfactory criteria for certifying individuals engaged in the carriage of dangerous bulk cargoes. The regulations, as proposed, would require new and/or additional classroom and field training for new and existing personnel.

The intent of this exercise was to identify the costs of these regulations to companies, government and personnel involved. The cost manual procedures section on vessel personnel licensing was used as a guide to developing these cost estimates.

The format for this case followed the format for current Coast Guard Economic Impact Statements. The procedures manual formats, used as a basis for the cost estimates, appear as a separate attachment to the Economic Impact Statement.

The results of this exercise were that significant numbers of existing personnel, as well as new personnel serving aboard vessels carrying dangerous cargoes in bulk would require training under the proposed regulations. MarAd and industry would bear the direct costs, with these costs likely to be passed on to the users of the products carried in tank vessels.

Example II - Double Hull Retrofits For Existing Tank Barges

This example involved proposed Coast Guard regulations to require design changes in existing tank barges carrying oil in bulk. In addition, the regulations would increase inspection frequency and repair standards for barges that were not retrofitted. This example was limited to the costs and cost impacts of retrofitting existing barges. The purpose of the regulations is to reduce pollution in the navigable waters of the U. S. The manual procedures for vessel design changes and vessel delays were used as the basis for this exercise.

Definitive cost estimates were not possible in the time available for the exercise. Since the retrofit requirements for existing barges was only one of a series of regulations affecting barge design criteria, actual cost estimates for barge retrofit should be considered in the context of the proposed regulations impacting barge design changes. However, the example is illustrative of the information and data required to carry out this analysis, problems encountered in this effort, the level of detail appropriate for this analysis and initial estimates of the costs of the proposed regulatory action under a specified set of circumstances.

One conclusion reached in the course of this exercise was that the high costs of retrofitting make it likely that only a small percentage of barges would undergo retrofit. Second, an accurate estimate of the costs of retrofit require an assessment of the ability of

shipyards to perform large numbers of retrofits within the time constraint of the regulations.

Example III - Vessel Delays At The Hackensack River Portal Bridge

This example was oriented to determining vessel traffic delay costs for alternatives concerning the replacement of Portal Bridge. The bridge is only one of several drawbridges across the Hackensack River at which commercial vessels experience delays. The interface of vessel traffic with increasing use of this drawbridge by passenger trains plus frequent mechanical failures has resulted in significant costs to users of the waterway and the economy of the area as these costs are passed on to consumers.

This example did not involve an analysis of new or revised regulations. However, the procedures manual was readily adapted to this problem since it involved estimating impacts on vessel operating costs caused by vessel delays. Only minor adjustments were necessary to several of the manual formats.

This example describes the approach and identifies the issues and key cost elements to be considered in analyzing this type of problem. No defensible cost estimates for this problem were possible within the time frame of the exercise. Cost estimates for this problem, particularly cost impacts, would require an analysis of vessel delays for the river system. In the course of the exercise it was determined that data for such a cost estimate were available. Additionally, analysis of the total costs of vessel delays at bridges along the Hackensack River could provide valuable input into the costs and benefits of alternative courses of action.

SECTION V

RECOMMENDATIONS

Based on the work effort described in the preceding Sections, the following recommendations are made:

- It is concluded that special economics expertise is required to maintain the manual particularly if all aspects of input-output modeling are to be understood. Two options appear feasible: (1) add an additional senior economist billet to the Coast Guard staff or (2) contract with a professional services firm to maintain the manual and perform cost-benefit analyses as required.
- The formats developed during subtask I-1-B require numerous manual calculations. It is likely that procedures developed during subtask I-3-A likewise will be complex and require a great deal of attention to detail. Following completion of subtask I-3-A, it is recommended that consideration be given to incorporating procedures developed into an automated cost-benefit model format.
- If the Coast Guard sees a continuing need for an annual subscription to INFORUM, it is recommended further discussions be conducted with the INFORUM staff concerning the water transportation data base. At present, the data for this sector are being derived from two sources: (1) "Operating Revenues, By Type of Transport" contained in ICC Annual Report Statistics of Class I, II and III Motor Carriers and (2) Transport Economics. The INFORUM staff suggested it may be possible to build a more comprehensive data base for this sector with the Coast Guard's assistance.
- The Coast Guard is charged with assuring safe operations within navigable U. S. waters. In addition, the Coast Guard has the responsibility to consider the economic consequences of its proposed regulatory actions. However, the ability to do the latter is greatly impaired under present conditions.

Therefore, it is recommended that consideration be given to the development of a management information system designed to support such mandatory economic analysis.

- Provide an exercise of the manual procedures dealing with cost impacts to ascertain their usefulness in the analyses of Coast Guard regulatory actions and to provide a documented example for future users of the manual.

SECTION VI
BIBLIOGRAPHY

Almon, C., Jr., et al. 1985: Interindustry Forecasts of the American Economy. Lexington, Massachusetts: D.C. Heath and Company, 1974.

American Petroleum Institute and the Tanker Council, American Institute of Merchant Shipping. Estimated Additional Cost of Segregated Ballast/Double Bottoms to Accompany Statement of the American Petroleum Institute and the Tanker Council, American Institute of Shipping. June 16, 1977.

Anderson, David L., et al. Modal Traffic Impacts of Waterway User Charges. Volumes I, II, III. Washington, D.C.: U.S. Department of Transportation, 1977.

----- and Robert W. Schuessler. Regional Market, Industry and Transportation Impacts of Waterway User Charges. Cambridge, Massachusetts: U.S. Department of Transportation, 1976.

Barker, James R. and Robert Brandwein. The U.S. Merchant Marine in National Perspective. Lexington, Massachusetts: Heath Lexington Books, 1970.

Baumol, W.J. "On the Discount Rate for Public Projects," in Robert Havemann and Julius Margolis, Editors. Public Expenditures and Policy Analysis. Chicago: Rand McNally College Publishing Co., 1970.

Benderly, et al. The Problems of Estimating Costs of Naval Ships. Washington, D.C.: The George Washington University, 1970.

Benford, Harry. Fundamentals of Ship Design Economics. Ann Arbor: University of Michigan, 1968.

-----, General Cargo Ship Economics. Ann Arbor, Michigan: University of Michigan, August 1965.

-----, Measures of Merit for Ship Design. Ann Arbor: University of Michigan, 1968.

-----, Of Dollar Signs and Ship Designs. New York: The Society of Naval Architects and Marine Engineers, 1975.

Bennathan, Esra and A. A. Walters. The Economics of Ocean Freight Rates. New York: Frederick A. Praeger, 1969.

Brown, Richard S., et al. Economic Analysis Handbook. Alexandria, Virginia: Naval Facilities Engineering Command, June 1975.

Bureau of Economic Analysis. Input-Output Table of the U.S. Economy: 1971. Washington, D.C.: Department of Commerce, 1977.

Chase Econometric Associates, Inc. Macroeconomic Impacts of Federal Pollution Control Programs. Prepared for Council for Environmental Quality. Bala Cynwyd, Pennsylvania: Chase Econometric Associates, Inc., 1975.

-----. The Economic Impact of Pollution Control: Macroeconomic and Industry Reports. Prepared for Environmental Protection Agency. Bala Cynwyd, Pennsylvania: Chase Econometric Associates, Inc., 1973.

-----. The General Economy. Prepared for Council on Environmental Quality. Bala Cynwyd, Pennsylvania: Chase Econometric Associates, Inc., 1972.

Chrzanowski, Ignacy. "Concentration in Shipping," Journal of Transport Economics and Policy, VIII (May 1974), 174-179.

Clark, Earl W., et al. The U.S. Merchant Marine Today: Sunrise or Sunset? Washington: Labor-Management Maritime Committee, 1970.

Defense Logistics Agency. Economic Analysis. Alexandria: Department of Defense, 1978.

Devanney, J. W., et al. "Conference Ratemaking and the West Coast of South America," Journal of Transport Economics and Policy, IX (May 1975) 154-177.

Dorfman, Nancy S. "Who Will Pay for Pollution Control? - The Distribution by Income of the Burden of the National Environmental Protection Program, 1972-1980." National Tax Journal, XXVIII (March 1975), 101-115.

Drewry, H.P., Ltd. Market Conditions and Tanker Economics. London: H.P. Drewry, Ltd., 1976.

-----. Tanker Chartering Through the 1970's. London: H. P. Drewry, Ltd., 1977.

-----. Repairing and Drydocking Large Carriers. London: H.P. Drewry, Ltd., 1974.

-----. The Scrapping of Ships. London: H. P. Drewry, Ltd., 1973.

Economic Research Center. Cost-Benefit Analysis. Paris: European Conference of Ministers of Transport, 1977.

Evans, Michael K. "A Forecasting Model Applied to Pollution Control Costs." American Economic Review, LXIII (May 1973), 244-257.

Ferguson, Allen R., et al. The Economic Value of the U.S. Merchant Marine. Evanston, Illinois: The Transportation Center at Northwestern University, 1961.

Fisher, Gene. Cost Considerations in Systems Analysis. New York: American Elsevier Publishing Company, Inc., 1971.

Frankel, E. G., and H. S. Marcus. Ocean Transportation. Cambridge, Massachusetts: MIT Press, 1973.

Franklin, Phillip E. The Economic Impact of Flag Discrimination in Ocean Transportation. Ann Arbor, Michigan: University Microfilms, Inc., 1968.

Freeman, A. Myrick. "The Distribution of Environmental Quality," in Allen V. Kneese and Blair T. Bower, Eds. Environmental Quality Analysis: Theory and Method in Social Science. Baltimore, Maryland: Johns Hopkins University Press, 1972, pp. 243-280.

-----. "Income Distribution and Planning for Public Investment," American Economic Review, LVII (June 1967), 495-508.

-----. "Six Federal Reclamation Projects and the Distribution of Income." Water Resources Research, III (Spring 1967), 319-331.

Friedlander, A. F. The Dilemma of Freight Transport Regulation. Washington, D.C.: The Brookings Institution, 1969.

Gillespie, W. Irwin. "Effects of Public Expenditure on the Distribution of Income," in R. A. Musgrave, Ed. Essays in Fiscal Federalism. Washington, D.C.: The Brookings Institution, 1965, pp. 122-181.

Goss, R. A., Editor. Advances in Maritime Economics. Cambridge, Massachusetts: Cambridge University Press, 1977.

-----. The Cost of Ship's Time. New York: Cambridge University Press, 1975.

-----. Studies in Maritime Economics. Cambridge: Cambridge University Press, 1968.

Harbridge House. The Balance of Payments and the U.S. Merchant Marine. Boston: Harbridge House, Inc., 1968. Reprinted in Barker and Brandwein, The U.S. Merchant Marine in National Perspective, Appendix C.

Hettich, Walter. "Distribution in Benefit-Cost Analysis. A Review of Theoretical Issues," Public Finance Quarterly, IV (April 1976), 123-150.

Hoicka, John, et al. Pollution Abatement and Unemployment: A Methodological Study. Prepared for Environmental Protection Agency. Washington, D.C.: Institute for Public Administration, 1972.

-----. "Prices in Input-Output." Draft Report. College Park: University of Maryland.

INFORUM. "Run Guide-Conversational Operation of U.S. Forecasting Model." College Park: University of Maryland, 1975.

Jansson, Jan Owen. "Intra-Tariff Cross-Subsidization in Liner Shipping," Journal of Transport Economics and Policy, VIII (September, 1974), 294-311.

Jantscher, Gerald R. Bread Upon the Waters: Federal Aids to the Maritime Industries. Washington, D.C.: The Brookings Institution, 1975.

Kilgour, John G. The U.S. Merchant Marine: National Maritime Policy and Industrial Relations. New York: Praeger Publishers, Inc., 1975.

Laing, Edward. Containers and Their Competitors: The Economics of Deep Sea General Cargo Shipping in the 1970's. Liverpool, England: The Transportation Center at University of Liverpool, 1975.

Lakshmanen, T. R. and Fu-chen Lo. "A Regional Economic Model for the Assessment of Effects of Air Pollution Abatement," Environment and Planning, IV (1972), 73-97.

Larner, Robert. "Public Policy in the Ocean Freight Industry," in Almarin Phillips, Editor. Promoting Competition in Regulated Markets. Washington, D.C.: The Brookings Institution, 1975.

Layard, Richard, Editor. Cost-Benefit Analysis. New York: Penquin Books, Ltd., 1977.

Leontief, Wassily. "Environmental Repercussions and the Economic Structure: An Input-Output Approach," in Robert Dorfman and Nancy Dorfman, Editors. Economics of the Environment. New York: W. W. Norton and Co., 1972, 403-422.

-----, Input-Output Economics. Oxford: Oxford University Press, 1966.

McGuire, Martin C. and Harvey Garn. "The Integration of Equity and Efficiency Criteria in Public Project Selection," The Economic Journal, LXXIX (December 1969), 882-893.

Maritime Administration. Joint Maritime Administration/Coast Guard Tanker Barge Study. Washington, D.C., 1974.

-----, Relative Cost of Shipbuilding: A Report of Congress. Washington, D.C.: Maritime Administration, 1977.

-----, "Title 46 - Shipping, Part 282 - Uniform System of Accounts for Maritime Carriers," Federal Register. May 9, 1974 (30 F.R. 16445).

Miernyk, William H. "A Regional Input-Output Pollution Abatement Model," IEEE Transactions on Systems, Man, and Cybernetics, III (November 1973), 575-577.

Mikesell, Raymond F. The Rate of Discount for Evaluating Public Projects. Washington, D.C.: American Enterprise Institute, 1977.

Mishan, E.J. Cost-Benefit Analysis. New York: Praeger Publishers, 1976.

Moll, Kendall, et al. Hazardous Wastes: A Risk-Benefit Framework Applied to Cadmium and Asbestos. Menlo Park, California: Stanford Research Institute, 1975.

-----, "Methodology Recommended for the National Research Council for Regulating Chemical Hazards," in David Okrent, Editor. Risk-Benefit Methodology and Application. Los Angeles: University of California, 1975, 391-414.

Murphy, Robert D., et al. Least Cost Ship's Characteristics by Computer Techniques, Washington, D.C.: U.S. Department of Commerce, 1963.

National Academy of Sciences. Decision Making for Regulating Chemicals in the Environment. Washington, D.C.: National Academy of Sciences, 1975.

National Economics Division. "Input-Output Structure of the U.S. Economy: 1973," Survey of Current Business XLIX (November 1969), 16-25.

Norsworthy, J. Randolph. Estimated Inflationary Impacts of Price Changes in Input-Output Industries. Washington, D.C.: Office of Emergency Preparedness, 1973.

Office of Management and Budget Circular Number A-94. Subject: Discount Rates to be Used in Evaluating Time Distributed Costs and Benefits, 1972.

Office of Maritime Manpower. "Deck and Engine Officers of the U.S. Merchant Marine: Supply and Demand, 1976-1985." Washington, D.C.: Maritime Administration, 1977.

Office of Policy and Plans Development. The Barge Mixing Rule Problem: A Study of the Economic Regulation of Domestic Dry Bulk Commodity Transportation. Washington, D.C.: U.S. Department of Transportation, 1973.

Office of Ship Construction, Division of Estimates. "Classification of Ship Construction and Reconstruction Costs." Washington, D.C.: Maritime Administration, 1965.

Office of Ship Construction. Handbook for Life Cycle Cost Analysis. Washington, D.C.: Maritime Administration, October 1970.

Office of Subsidy Administration. Vessel Inventory Report. Washington, D.C.: Maritime Administration, 1977.

Office of Trade Studies and Statistics. A Statistical Analysis of the World's Merchant Fleets. Washington, D.C.: Maritime Administration, 1977.

Peskin, H.M. and E.P. Seskin, Editors. Cost-Benefit Analysis and Water Pollution. Washington, D.C.: The Urban Institute, 1973.

Pruett, James M. Advanced Surface Craft Economic Model. New York: The Society of Naval Architects and Marine Engineers, 1976.

Russell, Clifford S. "Application of Microeconomic Models to Regional Environmental Quality Management." American Economic Review, LXIII (May 1973), 236-243.

Shipboard Mechanization and Manpower Committee. Shipboard Systems Costs: A Functional Analysis of Work Aboard Ship: Summary Report. Washington, D.C.: National Research Council, 1967.

Shneerson, D. "The Structure of Liner Freight Rates," Journal of Transport Economics and Policy, X (January 1976), 52-67.

Snell, Foster D., Inc. Study of the Potential Economic Impacts of the Proposed Toxic Substances Control Act as Illustrated By Senate Bill S. 776 (February 20, 1975). Washington, D.C.: Manufacturing Chemists Association, 1975.

Stament, A.D., et al. Economic Analysis Handbook: Theory and Application. McLean, Virginia: General Research Corp., 1973.

Stockfish, J.A. "Measuring the Opportunity Cost of Government Investment," IDA Research Paper R-490, March 1969.

Svendsen, Arnliot. Factors Determining the Laying Up of Ships. Bergen: University of Norway, 1957.

The Economic Impact of Pollution Control: A Summary of Recent Studies. Prepared for Council on Environmental Quality, Department of Commerce and Environmental Protection Agency, 1972.

U.S. Coast Guard. Commandant Notice 4140, June 1977. Subject: Annual Personnel Life Cycle Costs.

----- Commandant Notice 7100, April 1977. Subject: Annual Standard Personnel.

----- Enclosure to COMDTINST 16465.2A, November 1976. Subject: Standard Rates.

----- Fiscal Year 1978 Budget Estimates. Submission to Congress.

----- Inflationary Impact Statements - Inert Gas Systems, Segregated Ballast Retrofit and Double Bottoms, Improved Emergency Steering Capability. May 6, 1977.

----- Marine Inspection Office Workload and Billet Distribution Study. June 1974.

----- Marine Safety Manual. CG-495, Volume I, Washington, D.C.: Government Printing Office, October 7, 1977.

----- Operating Program Plan for Commercial Vessel Safety. July 1977.

----- Planning and Programming Manual. CG-411, July 21, 1977.

----- Report on Staffing Criteria for Documentation Offices, May 18, 1971.

U.S. Congress. Economic Analysis of Public Investment Decisions; Interest Rate Policy and Discounting Analysis: A Report. Joint Economic Committee, 90th Congress, 2nd Session, Washington, D.C.: GPO, 1968.

University of Michigan Engineering Summer Conference. Economics in Ship Design and Operation. Ann Arbor, Michigan: University of Michigan, August 1-5, 1966.

Weisbrod, Burton A. "Income Redistribution Effects and Benefit-Cost Analysis," in Samuel B. Chase, Jr., Ed. Problems in Public Expenditure Analysis. Washington, D. C.: The Brookings Institution 1968.

Yu, K. C., A Statistical Analysis of the Engineering Approach to Navy Shipbuilding Cost Estimation. Washington, D. C.: The George Washington University, Institute for Management Science and Engineering Program in Logistics, June 30, 1970.

Zechauser, R., et al. Benefit-Cost and Policy Analysis 1974. Chicago: Aldine Publishing Co., 1975.

END

DATE
FILMED

5 - 8 - 1

DTIC